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Water-Supply and Irrigation Paper No. 138 Series O, Underground Waters, 41

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

# DEVELOPMENT OF UNDERGROUND WATERS

IN THE

# CENTRAL COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA

BY

WALTER C. MENDENHALL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

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# CONTENTS.


| | Page. |
|---|---|
| Letter of transmittal | 7 |
| Introduction | 9 |
| The coastal plain | 10 |
| Soils and crops | 11 |
| Water supply | 12 |
| Irrigation systems | 13 |
| Rincon ditch | 14 |
| Cate ditch | 14 |
| Standefer or Ranchito ditch | 15 |
| Banta and Los Nietos ditches | 16 |
| Arroyo ditch | 16 |
| San Antonio ditch | 17 |
| Other distributing systems | 18 |
| Drainage district | 18 |
| Underground water | 19 |
| Sources | 19 |
| Distribution | 20 |
| Development | 22 |
| Effects of development | 23 |
| Permanence of the supply | 24 |
| Summary | 35 |
| Description of maps and tables | 35 |
| Acknowledgments | 38 |
| Well data | 40 |
| Index | 151 |

# ILLUSTRATIONS.


Page.

PLATE I. Artesian areas and hydrographic contours of the coastal plain of southern California ..... Pocket.

II. Map showing irrigated lands, canals, drainage districts, and pumping plants in the Downey and Las Bolsas quadrangles, California..... Pocket.

III. The inner edge of the coastal plain west of Whittier, Cal..... 10

IV. Map showing wells, artesian areas, and water levels in the Downey and Las Bolsas quadrangles, California..... Pocket.

V. *A*, Typical 10-inch well; *B*, Well No. 991, Downey quadrangle..... 22

FIG. 1. Chart showing departures from average rainfall at Anaheim, Cal..... 29

2. Chart showing departures from average rainfall at San Bernardino, Cal..... 31

3. Chart showing departures from average rainfall at Los Angeles, Cal..... 33

4. Diagram showing variation of water level near Anaheim, Cal..... 34

5. Map showing approximate amounts of dissolved solids in underground waters of coastal plain region of southern California..... 38

# LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
*Washington, D. C., November 3, 1904.*

SIR: I transmit herewith a report entitled "The Development of Underground Waters in the Central Coastal Plain Region of Southern California," prepared by Mr. W. C. Mendenhall, under the general direction of Mr. N. H. Darton, and recommend that it be published as a Water-Supply and Irrigation Paper.

This paper is similar to the one just published entitled "The Development of Underground Waters in the Eastern Coastal Plain Region of Southern California," and contains the results of work in the portion of the coastal plain just west of the area described in that paper. A third paper will treat of the area northwest of that here described and will complete the series of preliminary papers on the coastal plain of southern California.

The studies, a part of whose results are being made available in this way, are planned to cover all the important water-bearing lands of the valley of southern California. In most instances the facts gathered concerning the wells and the distributing systems will be supplemented by a study of the local geology, in so far as it controls the amount, distribution, and circulation of the ground waters. The hydrographic data and the geologic data will then be discussed and issued together in one report. In the coastal plain area, however, the geologic conditions being relatively simple, and the hydrographic data being large in volume and of paramount importance, it is deemed best to issue the latter at once, rather than to delay it pending the working out more fully of the comparatively unimportant geologic problems. Therefore the tables and maps are presented here for the consideration of water users, with a comparatively brief text, which is chiefly descriptive, but which includes a discussion of the effects of development and drought in bringing about those changes in water levels and in the outlines of artesian areas which have been most marked within the last five or six years.

Very respectfully,

F. H. NEWELL,
*Chief Engineer.*

Hon. CHARLES D. WALCOTT,
*Director United States Geological Survey.*

# DEVELOPMENT OF UNDERGROUND WATERS IN THE CENTRAL COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA.

By W. C. MENDENHALL.

## INTRODUCTION.

This paper is similar to Water-Supply Paper No. 137, on the "Development of Underground Waters in the Eastern Coastal Plain Region of Southern California." It contains the data gathered by the Survey in the Downey and Las Bolsas quadrangles,[a] just west of the two quadrangles described in the earlier publication. It includes tables of the wells, with data as to their position, depth, diameter, cost of installation, and yield, and maps of the irrigated lands and distributing systems. These data give a résumé of the individual experiences of well owners in the region as well as of the general effects of the great amount of development which has taken place within the last ten years.

By the valley of southern California is meant that lowland area extending from Santa Monica to Redlands, and from the base of the San Gabriel and San Bernardino ranges southward 30 or 40 miles. It includes the coastal plain, the broad portions of the Santa Ana, San Gabriel, and Los Angeles river valleys, and the irregular groups of hills which add picturesque variety to these lowlands and separate them into distinct tillable areas. Much of this region is intensively cultivated. The foothill belt from Pasadena eastward to Ontario, the Riverside Mesa lands, and the Redlands and Highlands benches are justly famous citrus regions, where agricultural lands have high values. In the coastal plain, which is not so well adapted to citrus culture, there is greater agricultural diversity; dairying, market gardening, the raising of deciduous fruits and vegetables and of English walnuts, celery, and sugar beets being important industries.

[a] A quadrangle is the unit of survey adopted by the United States Geological Survey for the topographic and geologic atlas of the United States. It is a rectangular area 15 minutes, 30 minutes, or 1 degree in extent each way, bounded by parallels and meridians, and having an area of one-sixteenth, one-quarter, or 1 square degree. The quadrangles disregard political boundaries, such as those of States, counties, and townships. To each is given the name of some well-known place or feature within its limits. A sheet is the topographic map of one of the above areas.

In all of this agricultural and horticultural activity, the first requisite is water. The entire region is semitropic and semiarid and irrigation is necessary in order to mature any except a few of the less valuable crops. As is generally the case in regions of little rain, the soils are rich because they have not been leached of their soluble fertile elements, and when water is applied to them they yield abundantly. As is fully recognized by agriculturists, constant sunshine and warmth, with the artificial application of water in the right quantities at the right times, give ideal conditions for large yields; hence the lands in arid or semiarid regions, when brought into cultivation by means of an abundant artificial water supply, are much more valuable than those in regions of greater rainfall, where irrigation is not practiced.

In southern California lands under irrigation usually bring several hundred dollars per acre, are not infrequently valued at $1,000 per acre, and may, in exceptional cases, bring $2,000 or even more. Since the greater part of the cultivable dry lands quickly acquire such values when water is applied to them, the story of the growth of this region becomes a story of the utilization and application of its available waters. To the practical solution of water problems, engineering and legal, much of the best talent of the country has been devoted for many years, and will be for many years to come.

The first settlers, the Mission Fathers, after them the Mexicans, and still later the Americans, secured their first holdings near the flowing streams or the "ciénaga" lands, the sites of perpetual springs. As the areas under cultivation slowly increased, the waters of the mountain canyons were gradually appropriated and applied to the adjacent lands. Then engineering devices were resorted to for increasing the flow of springs, for intercepting the underflow of streams, or for storing the flood waters by means of dams and reservoirs. Lastly, attention was turned to the underground waters, which proved to occur in large quantities and to be widely distributed, so that entire communities have sprung up which depend wholly on these sources for their irrigation water. Developments during the last ten years have been chiefly those of underground sources, and the maps and tables in this paper show their extent in a small part of the valley of southern California. (See Pls. I, II, and IV.)

## THE COASTAL PLAIN.

The district under immediate consideration is the central portion of the coastal plain of southern California. This plain extends inland from the Pacific Ocean 15 or 20 miles to the base of the hills which represent the Coast Range, and stretches coastwise for 50 miles from Sherman to the foot of the San Joaquin Hills. It is generally level or gently sloping, is fringed on the coastward side by a belt of salt marshes and sand dunes, and has an area of 775 square miles.

THE INNER EDGE OF THE COASTAL PLAIN WEST OF WHITTIER, CAL.

On the northeast it is bounded by the Santa Ana Mountains and their extension, the Puente Hills. Near the Pacific its even surface is interrupted by a line of low hills which, in the vicinity of Huntington Beach and Los Alamitos Bay, lie close to the coast, but which to the northwest are found farther inland as the shore line swings westward about San Pedro Hill. This line of low hills of irregular height marks the seaward boundary of the coastal artesian belt. As a topographic feature it is broken by the valleys of Santa Ana, San Gabriel, and Los Angeles rivers which cross it on their way to the sea; but as a structural feature and as a barrier to the subterranean waters which percolate slowly seaward, it appears to be continuous throughout. The Downey and Las Bolsas quadrangles, which constitute the central coastal plain region, include an area that extends from the shores of the Pacific at San Pedro Bay across the coastal plain to its inner edge in the neighborhood of Whittier and the Paso de Bartolo (Pl. III). These quadrangles lie about midway of the east-west extent of the plain and include the broadest part of the artesian belt; they contain more wells than any area of equal size in southern California.

The greater part of this area is underlain by loose sediments—sand, gravels, and clays—which were brought down from the mountains by the rivers and distributed by them and by the waves and currents of the Pacific off the shore of this part of the continent. The coastal plain is believed to have been at one time a broad embayment with San Pedro Hill as an island well offshore, as Santa Catalina is now. As a result of the accumulation of the débris brought out by the streams, and perhaps also in part as a result of uplift through crustal movement, this great bay has been reclaimed from the sea, and is now a prosperous and, throughout much of its area, densely settled agricultural region.

## SOILS AND CROPS.

The soils of the Downey and Las Bolsas quadrangles do not exhibit the great diversity found in some areas of the same size in the southern part of the State, although a number of more or less distinct varieties are recognized and mapped by the Agricultural Department.[a] The soils are rather uniform in texture, ranging only from the sands or fine gravels of San Gabriel Wash or of the beach dunes, to the dark adobes of the marshes and tule lands. They vary in origin from the washes brought by the streams from the distant mountains to the clays of the benches east of Whittier, which are derived from the Tertiary shales of the adjacent hills. They include the rich loams of the peat swamps, which owe their fertility in part to the vegetable

[a] Mesmer, Louis, Soil survey of the Los Angeles area. Field Operations Bureau of Soils, U. S. Dept. Agriculture, 1904.

mold which has accumulated through the decay of plant growths. These soils are generally productive, except in the sandy washes or dunes and in some of the lower lands where alkalies are found in excess. The latter trouble probably can be remedied by drainage in all cases, but few systematic attempts have yet been made in this direction. The more alkaline lands are generally included in the wide pastures of the larger undivided ranchos.

The crops exhibit the diversity which is characteristic of the coastal belt. On the benches about Whittier are extensive citrus orchards. In the lowlands, under the San Gabriel irrigation systems, are many flourishing walnut groves and orchards of deciduous fruits. Berry growing, gardening, alfalfa raising, dairying, and grape culture are practiced about Florence and Compton. Sugar beets and alfalfa are raised in quantities in the vicinity of Los Alamitos, and celery, potatoes, corn, and fruits are grown in the fertile and highly cultivated peat-land region south of Westminster.

Large parts of the Los Cerritos, Los Alamitos, and Los Coyotes ranchos are not under cultivation, but are reserved as pasture lands and stock ranges. As these ranchos include considerable areas of moist land, grazing is possible throughout the year over much of their acreage without irrigation.

## WATER SUPPLY.

Both the surface and the subsurface waters of the Downey and Las Bolsas quadrangles are supplied largely by San Gabriel and Los Angeles rivers. Part of the underground waters of the southeastern portion of this area are probably contributed by the Santa Ana drainage system. These three streams, the largest in southern California, carry to the Pacific almost all of the run-off from the southern and western faces of the San Gabriel and San Bernardino ranges, which are the most effective mountain masses in this section of the State from the point of view of their capacity to induce precipitation. This is due to their height and to the fact that no high land intervenes between them and the Pacific, whence the moisture-laden winds come.

The channel of each of these streams, in its passage seaward from the mountains, crosses one or more wide valleys filled with loose sands and gravels. The waters are absorbed by this débris, and percolate slowly through it, beneath the surface, to reappear at some lower point where an obstruction to the underground passage forces them to the surface. At these points the underground waters become surface flows again, until absorbed later by another body of loose material. Thus the Santa Ana sinks in the wash above Redlands, rises to the surface above the Bunker Hill "dike," sinks below it, rises from Riverside to Bedrock Canyon below El Rincon, sinks in

the wash above Santa Ana, and finally partly rises again in the large peat-land springs about Talbert. The San Gabriel and the Los Angeles exhibit the same characteristics, but disappear and reappear less often in their much shorter courses to the sea.

This natural habit of the streams has been more or less seriously interfered with by the irrigation systems developed since the settlement of the region. At present irrigation canals head at the mouth of the mountain canyon from which each stream first debouches upon the plain, and at every place where the subterranean waters reappear the water is distributed upon the adjacent lands, where a much smaller proportion of it sinks and joins the underflow than before it was thus diverted.

The winter flood waters, which have always furnished the most important addition to the underground supply, are interfered with but little by the irrigation developments, and are still available for the annual recharge of the gravels.

## IRRIGATION SYSTEMS.

The only important system of canals in the Downey and Las Bolsas quadrangles is the one which diverts the San Gabriel River waters that rise to the surface in the neighborhood of the Paso de Bartolo (see Pl. II). A number of ditches here, some of them among the oldest in southern California, take out the river water as it rises in springs, and distribute it over the irrigable lands in the neighborhood of Whittier, Rivera, Downey, and Norwalk.

The available measurements of flowing waters at the Paso de Bartolo are as follows:

*Discharge measurements at the Paso de Bartolo.*

| | Discharge. | | |
|---|---|---|---|
| | Aug. 7, 1900. | Oct. 2, 1903. | Oct. 5, 1904. |
| | *Second-feet.* | *Second-feet.* | *Second-feet.* |
| Sheep Creek ditch | 2.46 | 4.6 | 1.35 |
| Rincon ditch | 2.47 | 3.4 | 1.5 |
| Old Temple ditch | 1.20 | ..... | ..... |
| Cate ditch | 8.71 | 5.5 | 11.1 |
| Standefer ditch | 14.56 | 14 | 12.9 |
| Banta and Los Nietos ditches | 15.44 | 28 | 19.5 |
| Rio Hondo under Mission bridge | 23.18 | 29 | 22.19 |
| Baldwin's ditch | ..... | ..... | 2.89 |
| Total | 68.12 | 84.50 | 71.43 |

It is to be expected that October measurements will be higher than those of August, the evaporation being lighter in the fall, but the effect of the greater rainfall preceding the summer of 1903, as compared with the summer of 1904, is clearly shown in the difference between the two October measurements. None of the waters measured are developed waters, and none of them reach the pass as surface streams All represent underflow below the mesa lands north of the pass, forced to the surface by the constricted character of the outlet and the comparative nearness of bed rock to the surface.

The following brief descriptions of some of the principal ditches which take their supply from this region and distribute it over the irrigable lands south of the pass are summarized in part from William Ham. Hall's "Irrigation in Southern California." They are brought up to date by additional information gleaned from various sources.

### RINCON DITCH.

This ditch is nearly 6 miles long and takes its water from San Gabriel River about 2 miles below the Southern Pacific Railroad crossing. It was built by Mr. Strong in 1871. It is about 4 feet wide on the bottom, unlined except in the vicinity of the pumping plant, and carries a variable depth of water. The land which it serves lies in the Paso de Bartolo and along the upper edge of the coastal plain just west of Whittier. In 1888 about 586 acres were reported as served by the ditch, and in 1904, 800 acres. In 1902 the supply of water from the river was augmented by the installation of a pumping plant, which is now used to make up the deficiency in the river supply. In 1904 this plant was in operation for about four months, day and night, and produced during that time about 120 miner's inches. The pumping company is incorporated as the Rincon Irrigation Company, but its stockholders are the irrigators owning land served by the ditch.

### CATE DITCH.

This ditch, built by J. W. Cate in 1867, takes its waters from the San Gabriel at about the point where the stream deserted its old channel in the flood of 1867–68. The ditch is about 3¾ miles long, and serves an area lying in and below the Paso de Bartolo and between Rio Hondo and San Gabriel River. The amount of land irrigated by this ditch has remained nearly constant, for 1,200 acres were reported under irrigation in 1880, 1,300 acres in 1886, and 1,300 acres in 1904. Until 1900 the ditch was of earth construction and the loss of water by seepage was considerable. On April 19 of that year the water users incorporated as the Cate Ditch Water Company, with 3,600 shares at $1 per share. Money was borrowed and improvements were at once undertaken. At present (January 1, 1905,) one-half mile at the head of the ditch

and 1 mile at the lower end of the ditch remain unimproved, over 2 miles are cemented, and 1,000 feet of wood flume have been put in. These improvements are reported to have cost about 50 cents per running foot. The water stock is appurtenant to the land and is nontransferable. The thirty-five irrigators are assessed $1 per acre to cover running expenses and interest and to provide a sinking fund. The expenses are low, the cost of repairs on the dam and charges for cleaning, improving, and maintaining the ditch amounting to only about $350 annually.

When water is abundant in the spring the ditch is divided into three heads; in the summer, when the amount available is less, but two heads are available, and at times of particularly low water there is only enough for one head. A "head" under these conditions is a variable quantity, but is said always to exceed 100 miner's inches. The period of rotation varies from twelve to sixteen days. Each irrigator in turn has the use of a head of water for thirty minutes per acre, except when the ditch carries but one head, when the period is reduced to fifteen minutes.

The available measurements of the flow in the Cate ditch follow:

*Flow in Cate ditch, California.*

| | Miner's inches.[a] |
|---|---|
| August, 1900 | 435 |
| October, 1903 | 275 |
| October, 1904 | 555 |

## STANDEFER OR RANCHITO DITCH.

This ditch was constructed in 1871 by settlers who had purchased lands on the Paso de Bartolo Rancho from Pío Pico. Its title is inherited by prescription and riparian ownership from the rancho, whose proprietors had used the water, although in a very unsystematic way, for years. The diversion from the San Gabriel is by a sand and brush dam, owned and constructed by the Standefer, Banta, and Los Nietos ditches jointly, at about the narrowest part of the pass. The main ditch is over 3 miles long and discharges into San Gabriel River below the Santa Fe Railroad. During the past two or three years the Pallett and Walnut branches and about 2,800 feet of the main ditch have been cemented. The rest is of earth construction. In 1902 the irrigators under this ditch incorporated on a basis of 10 shares per acre, or 13,000 shares in all. The expenses of cleaning and maintenance, zanjero's fees, etc., are met by charges of 10 cents per hour per head for day service and 5 cents per hour for night service. The ditch carries three or four heads of 150 to 200 inches. Charges for new construction, cementing, etc., are met by special assessments.

[a] The old California miner's inch is used throughout this report. It is equivalent to 9 gallons per minute, one-fiftieth second-foot, or 14.478 acre-feet per year.

## BANTA AND LOS NIETOS DITCHES.

The Los Nietos ditch, which was built previous to 1838 by Don Pío Pico, the grantee of the Paso de Bartolo rancho, and the Banta ditch, built by P. Banta in 1867, have used the same canal for about 2 miles below their diversion works since 1884, when the original upper Los Nietos ditch was destroyed by flood. Below the section which is owned and operated jointly, the Banta ditch is about 2 miles long and serves about 800 acres southwest of Whittier and below the lands watered from the Rincon ditch. Twenty-three irrigators are served by this ditch at present (1904).

The Los Nietos ditch extends south about 3½ miles from the point of its diversion from the Banta ditch and serves about 1,000 acres lying just east of San Gabriel River. In 1885 its interests were incorporated on the basis of 1,500 shares, which are not transferable out of the district.

The total flow in the San Gabriel at the headworks of the Standefer, Banta, and Los Nietos ditches, which was estimated at from 1,200 to 1,500 miner's inches in 1888, is proportioned among the three ditches in the order named in the ratio of 12:9:7, the division being effected on the following basis: The total flow is divided into four parts, each ditch receiving one part and the remaining fourth being shared by the Standefer and Banta ditches, the former receiving the water five and the latter two days in each week.

The combined flow of the two ditches on August 7, 1900, as determined by S. G. Bennett, was 772 inches, and on October 2, 1903, as measured by W. B. Clapp, was 1,400 inches. October 5, 1904, Mr. Clapp reported 975 inches at the headworks.

## ARROYO DITCH.

This ditch takes its supply from Rio Hondo, about 2 miles below the pass, and serves a large district lying east of this stream and west of the territory supplied by the Standefer ditch and its extensions.

The canal was built in 1869 and succeeded an earlier crude ditch which was really an old arroyo into which water had been diverted. The title is inherited from the riparian rights of the Rancho Santa Gertrudes, but no systematic attempt was made to use the water prior to the subdivision and sale of the rancho by Governor J. G. Downey in the late sixties.

In 1885 the irrigators organized the Arroyo Ditch and Water Company, which was incorporated with a capital stock of $22,500. Before this time more or less indefinite attempts at organization had been made, but they were only partially successful. Indeed, about fifteen irrigators owning lands near the head of the ditch finally refused to join in the incorporation, but successfully defended their right to the

use of their proportion of the water. At this time there was much internal dissension among the various irrigators supplied by it.

The total length of the main line from the intake below the pass to the terminus, 1½ miles south of Downey, is about 7 miles; the Sandridge branch, which leaves the main ditch at the crossing of the Santa Fe Railroad, is about 4 miles long.

In 1888 the ditch was reported to have a minimum supply of about 1,200 inches, and to serve about 3,800 acres. The acreage supplied by it has varied but little, being about 4,000 in 1871 and in 1903. The flow of Rio Hondo at the Mission bridge, all of which is diverted below into the Arroyo ditch, is reported by W. B. Clapp as follows:

*Flow of Arroyo ditch, California.*

| | Second-feet. |
|---|---|
| August, 1900 | 23.18 |
| October, 1903 | 29 |
| October, 1904 | 22.19 |

## SAN ANTONIO DITCH.

This ditch is supposed to serve a few hundred acres lying west of Rio Hondo and midway between the Southern Pacific and Santa Fe railroads. It uses the upper part of the Arroyo ditch, and later delivers 135 inches of water to the Gage ditch. It is of sand and earth construction throughout, is poorly cared for, and choked with weeds, so that little or no water is actually delivered to the lands served.

The water at the head of the Arroyo ditch was originally divided equally between that ditch on the one hand and the San Antonio and the Foster, or Gage, ditches on the other, the right of the Foster to 135 inches being acknowledged.

The Arroyo Ditch Company at an early day improved the upper part of its canal and thereby effected a saving of 100 inches. As the San Antonio Ditch Company declined to share in the cost of this improvement, the water saved went to the Arroyo ditch in accordance with the terms of an agreement entered into in 1885. Recently further improvements have resulted in an additional saving, also claimed by the Arroyo Ditch Company, which has borne the expense of the improvements.

The title to this last increment, however, is not admitted by the San Antonio Company, and the matter is not as yet finally settled.

The basis of division now is this: The first 100 inches belongs without dispute to the Arroyo Ditch Company, and the first 235 inches is claimed by them. The remainder is divided equally between the San Antonio and the Gage ditches on the one hand and the Arroyo ditch on the other. Of the first part 135 inches is assigned to the Gage ditch. The part remaining after this is taken out belongs to the San Antonio ditch, but as it flows for 2 miles through the sandy bed of Rio Hondo a large part of it seeps away and is lost.

## OTHER DISTRIBUTING SYSTEMS.

In addition to these principal ditches which have been mentioned, the Little Lake ditch, the Section Line ditch, the Agricultural ditch, and the New River ditch represent lower diversions from the San Gabriel, which receive such excess as may be left after the older rights are satisfied. Their supplies are received chiefly in the winter season.

The town of Whittier secures its domestic supply from two wells just east of San Gabriel River, on the Whittier-Los Angeles road. The water is pumped from these wells into a reservoir on a knoll above the village, whence it is distributed by gravity.

Long Beach and Los Alamitos Beach are supplied by flowing wells in the artesian basin, north of Signal Hill.

Part of the Long Beach supply reaches the town by gravity from the vicinity of Bixby station; another portion flows into a reservoir and is pumped thence into higher reservoirs on Signal Hill, whence it is distributed. This latter plan is followed by the Alamitos Beach Water Company.

Another important line not yet mentioned is that owned by the East Whittier Water Company. The water supply in this case is not secured from the water-bearing lands of the coastal plain but from the San Gabriel Valley, north of the Paso de Bartolo, near Woyden Station, on the Southern Pacific. A well-equipped air-pumping plant has been installed here and coupled with a number of wells. The water thu developed is conveyed by flume, covered ditch, and cement and steel pipe lines to the lands served in the East Whittier and La Habra districts. This system of covered and lined canals throughout is an example of a modern up-to-date distributing plant.

## DRAINAGE DISTRICT.

In Water-Supply Paper No. 137, on the underground waters of the eastern coastal plain region, the Bolsa and the Willows drainage districts of the peat lands of Orange County have been briefly described. The greater part of the older of these two districts, the Bolsa, is on the Las Bolsas quadrangle. Its outlines are shown on Pl. II.

The earliest ditch in this district is reported by Mr. W. B. Lamb to have been dug twenty or thirty years ago by the Stearns Rancho Company. Later the county improved and extended this original ditch, and finally, in 1899, the Bolsa drainage district was organized under a State law passed two years before.

Under this law three commissioners were elected especially to make a levy upon the district for the maintenance and extension of the ditch. These commissioners levied $15,000 for the expenses of the first ten years, but the amount will not prove sufficient, and an additional levy is expected within a year or two. The expenditures each

year are determined by a board of three directors elected to serve two years. They decide year by year the amount of the original levy that is to be expended. When this annual levy has been determined, it is collected by the county from the landowners within the districts, and the expenditures are then paid by warrants drawn upon the county treasurer.

About 15 miles of ditch are reported within the district, and the annual maintenance charges, exclusive of new construction, are given as about $1,000. Several miles of private drain have been put in, with outlets in the main ditches. The land has thus been greatly improved, until now the district contains some of the most valuable of the famous Orange County peat lands.

## UNDERGROUND WATER.

### SOURCES.

The chief supply for the underground as well as for the surface waters of the Downey and Las Bolsas quadrangles comes from Los Angeles and San Gabriel rivers, both of which flow across the Downey quadrangle; another portion of it is probably furnished by Santa Ana River, whose surface channel lies entirely to the east of this area, but whose percolating subsurface waters may contribute to the underground supply in the Las Bolsas quadrangle and in the southeastern part of the Downey quadrangle. An unknown, but no doubt minor, amount is contributed by the summer underflow of these streams, and that part of the surface flow that is not lost by direct evaporation or by transpiration through the plants, in the process of irrigation for which it is all utilized, also becomes available. This proportion of return water must vary greatly with locality, soil, and manner of irrigation. On the mesa lands, whose soils are warm and dry and are often underlain by an impervious hardpan, and whose water supply is expensive and never used in excess, the proportion of return waters must necessarily be small. On the other hand, on the sandy lands between San Gabriel River and Rio Hondo, where water is applied in abundance, sometimes in excess, upon a sandy absorptive soil, the return must be large; here it is probably much more than the 30 per cent which is often assumed as the proportion of return waters. A third minor source of supply is the light surface and subsurface drainage from the adjacent slopes of the Puente Hills. This yields a relatively small amount. The winter season is the period of most effective restoration of the subterranean supply. The direct rainfall upon the coastal plain averages approximately 12 inches, almost all of which falls at that time; but the most important sources are the flood waters of the streams and the usual normal winter flow, a smaller proportion of which is utilized for irrigation when the rains reduce the necessity for the latter.

As these flood waters pass over the sandy washes they are absorbed rapidly and are thus added to the underground stores. A proportion of the greater floods often escapes absorption by reaching the sea over the surface. It is thus wholly lost.

In considering the sources of these underground waters there may be dismissed at once the suggestion that the sea water, by some great extension of the power of capillarity, is drawn inland and freed of its salt, or that a portion of the waters of Colorado River, or some equally distant stream, flows in an underground channel through the great intervening mountain barriers. These theories have no basis in fact, and are generally expressions of wishes rather than of sober belief.

## DISTRIBUTION OF UNDERGROUND WATER.

Since the coastal plain is underlain by irregular sheets of more and less pervious material—gravels, sands, and clays—which slope gently toward the sea and increase in coarseness inland, the underground waters that percolate seaward along the coarser beds are often caught beneath a less pervious layer and accumulate pressure from the weight of the water behind them. A bed of open material may wedge out seaward between impervious strata, or may abut against an earlier ridge, or may, with the beds above and below it, be folded into an anticline, or may become gradually finer and less permeable seaward, so that the escape of its waters in that direction is cut off or rendered less easy than their entry farther inland. Under these conditions, whenever the overlying confining stratum is penetrated by a pipe or a drill, the confined waters tend to rise to the level of their source. This is the general explanation of the artesian conditions which exist here.

Since the percolating waters gravitate seaward and the finer beds, which are as essential to artesian conditions as the coarser, occur more often along the lower portion of a stream's course, it follows that the artesian areas are in the lower parts of a basin distant from canyon mouths, where only comparatively coarse detritus is deposited. All of the southern California streams are alternately surface and subterranean, the Santa Ana, San Gabriel, and Los Angeles each disappearing and reappearing several times between the mountains and the sea. The area in which the surface channels, during the summer seasons at least, are dry, is always a wide valley region; while the waters flow on the surface either in canyons, where bed rock is near the surface, or in open plains, where there is an effective, if inconspicuous, obstruction to the subsurface circulation.

Near the lower edge of practically every lowland in the valley of southern California across which a stream flows is an artesian basin, large or small, whose existence is due to conditions like those just outlined. After the waters escape from one such basin and flow

over its lower rim, the conditions are duplicated in the next basin below, and artesian waters are again found there. Thus, the waters of the Santa Ana first pass through the San Bernardino artesian belt. They escape over its lower rim, the "Bunker Hill dike" above Colton, and again sink and enter the small and unimportant Riverside basin. At Riverside Narrows they are forced out by the proximity of bed rock, flow over the surface through the lower Santa Ana Canyon, and finally enter the coastal plain artesian belt. At a point farther north than the mouth of the Santa Ana, where a wider strip separates the lower edge of the coastal plain artesian area from the Pacific, waters from this belt again occur under pressure in the small Ballona artesian area near Playa del Rey (Pl. I).

Where other conditions, such as amount of water available, are equal, those artesian basins which exist along the upper portion of a stream, though smaller, should be more efficient than the basins lower down, since near the source of the débris the water-bearing strata are usually coarser and more abundant. Such coarse strata yield their water more readily, giving wells of greater flow, and are replenished more quickly after exhaustion because they absorb flood waters with greater rapidity. At such a higher point, however, conditions are less favorable for the widespread deposition of the fine, relatively impervious clays, which are as essential as the coarser beds to the existence of artesian basins, hence the higher artesian basins are apt to be less extensive than those farther downstream, although they yield water more readily and are therefore perhaps more likely to be exhausted by reckless development.

The coastal plain artesian basin is much the largest of a number of basins which occur at various points between the sources and the mouths of the rivers of this part of southern California. It is in fact a union of the lowest basins of the three principal streams of this part of the State. Its area at present (August, 1904) is about 190 square miles. Originally it was somewhat less than 300 square miles. A large part, both of the present and of the original coastal belt, is included in the area treated in this report—the Downey and Las Bolsas quadrangles. There are now approximately 121 square miles of artesian water-bearing lands in this area, 105 square miles in the Downey quadrangle, and 16 square miles in the Las Bolsas quadrangle (Pl. IV).

There has been no decrease in the artesian area in the Las Bolsas quadrangle, because it lies along the lower edge of the artesian lands, the last portion to be affected by dry years or by excessive drafts. The artesian area in the Downey quadrangle has decreased 45 square miles, or 30 per cent from the original 150 square miles. The southwestern seaward edge of this basin is marked by a low, irregular ridge, whose highest point, Los Cerritos, 2½ miles northeast

of Long Beach, is 364 feet above sea level. Dominguez Hill, another prominent point west of the channel of Los Angeles River, has an elevation of 195 feet. Toward Huntington Beach the ridge is lower and indeed is entirely cut away for several miles by the outlets of San Gabriel River, Anaheim Creek, and Bolsas Creek, so that along the coast between Los Alamitos Beach and Huntington Beach only isolated knobs, like Landing Hill, Bolsa Chica, and Las Bolsas exist as surface expressions of the underground structure that acts as a barrier to the subterranean waters in their slow movement seaward.

Beyond the artesian area, both north and south, are broad belts in which the water is not under sufficient pressure to flow but is near enough to the surface to be readily available for pumping. Such belts include areas that were originally artesian. They extend, on the one hand, to the base of the Puente Hills or to the northern edge of the Downey quadrangle, and on the other, practically to the shores of the sea. The position of the surface of the zone of saturation throughout the areas where the ground water is important as a source of supply is shown on Pls. I and IV by means of contours drawn upon that surface as a plane. The depth to the ground-water level at any point may be determined by subtracting the altitude of the ground-water level, as shown by the hydrographic contours, from the altitude of the surface, as shown by the topographic contours.

## DEVELOPMENT OF UNDERGROUND WATER.

In the Downey quadrangle there are more than 3,000 wells, all of which draw to a greater or less extent on the underground supplies. In the adjacent Las Bolsas quadrangle there are 300 wells. Of this total of 3,300, 175 are equipped with pumping plants operated by electricity, steam, or gasoline. These plants represent an investment of about $150,000, and the wells upon which the pumps have been installed have cost about $75,000; the pumped wells and their installation, therefore, represent a capital of $225,000.

Of the 3,300 wells, about 1,635, nearly one-half, were artesian in the spring of 1904, and their estimated cost—the estimate being based on reports from about 800—was $400,000.

There are about 700 windmill wells in the area, which, with the mills with which they are equipped, represent an outlay of approximately $200,000. The 790 domestic wells that make up the balance of the 3,300 must bring the total capital invested in wells and equipment in the Downey and Las Bolsas quadrangles to the neighborhood of $1,000,000. This is independent of the money invested in ditches, pipes, or other devices for the distribution of the water for irrigation.

*A.* TYPICAL 10-INCH WELL.

*B.* WELL NO. 991, DOWNEY QUADRANGLE.

The possible yield of these wells is very large. The output of the pumping plants when in service, based upon the measured or reported yield of five-sixths of their number, is 265 second-feet. The flow from 685 of the 1,635 artesian wells is over 200 second-feet, an average of about 15 miner's inches to each well. If this average is maintained by each of the 1,635 wells, the total yield approaches 500 second-feet, and the combined capacity of the pumping plants and artesian wells exceeds 750 second-feet, or 37,500 miner's inches. It is difficult to estimate how much of this yield is actually used. The pumping season varies from fifty to one hundred and twen y-five days usually. As artesian water is cheaper than pumped water it is used more freely, and many wells flow unchecked throughout the year. Others are open only during the actual irrigating season. On the whole it is considered conservative to estimate that the yield of 750 second-feet is maintained for two or three months of the twelve, equivalent to a continuous withdrawal of developed water amounting to from 125 to 200 second-feet throughout the year from the 268 square miles of the coastal plain which are included in the Downey and Las Bolsas quadrangles.

## EFFECTS OF DEVELOPMENT OF UNDERGROUND WATERS.

This development, which began in a small way forty years ago and has continued at an accelerating rate since, the increase in the number and aggregate yield of wells having been particularly marked during the last decade, must inevitably affect the quantity of water in the underground reservoir from which the wells draw.

Before development began the outlines of the artesian basin and the ground-water level expressed a condition of balance between the supply and the natural drainage at that time. With any marked increase in supply, such as may have been brought about by a series of years of excessive rainfall, the ground-water level would rise, increasing the flow from all sources fed by it, and the artesian area would expand and pressure within it would increase, thus increasing the yield of those springs and streams whose sources were artesian waters, until this increased discharge balanced the temporarily increased supply, and a condition of stability resulted. Similarly, during a series of dry years the ground-water level fell and the artesian area contracted, until drainage declined to an equality with the decreased supply. Thus ground-water levels and artesian areas varied within certain limits previous to the change in conditions brought about by development. But with the appearance of man upon the scene, disturbing elements were introduced. The first change in natural conditions consisted of the diversion of the normal summer flow of

streams, which before the diversion sank and added their volume to the stored subsurface waters. A part of this flow, it is true, was added to the underground supply after diversion in the form of return waters from irrigation, but the amount thus added, while a variable proportion of the original, is always distinctly a minor part of it. It may be roughly estimated to run from 5 to 50 per cent of the whole. Thus the supply was sensibly diminished. Meanwhile, the boring of numerous wells in the artesian area increased the freedom of drainage. This factor at a later stage of development was rendered more important by the installation of pumping plants outside of the artesian belt. The water secured by these means, like that secured by stream diversion, was largely used for irrigation and a portion of it thus returned to augment the ground-water supply. Yet transpiration through the plants and evaporation in the ditches, and especially from the soil surface in the process of irrigation, dissipates the greater part of the water thus applied.

These two disturbing elements—the decrease of supply and the increase of drainage through development—must destroy the balance reached before they were introduced, and bring about a readjustment of the ground-water level and a rearrangement of the outlines of the artesian areas. Since they both operate in one direction, namely, to lessen the amount of ground water, the readjusted water level must stand at a lower point than the original level, and the new outlines of the artesian area must be within the original outlines.

## PERMANENCE OF UNDERGROUND-WATER SUPPLY.

The entire coastal plain, underlain everywhere by saturated sands, gravels, and clays, has an extent of 775 square miles. Under about one-fourth of this area the waters are under pressure and are artesian. The thickness of these saturated gravels is unknown, but wells more than 1,300 feet deep near the inner edge of the plain fail to reach bed rock. It is safe to say that over much of the area their thickness must be expressed in thousands rather than in hundreds of feet. There can be no doubt that practically all of this mass is saturated, so that the total amount of water which exists there is enormous. Its sole source is the rainfall within the drainage basins tributary to the coastal plain, but the gravels themselves and the water saturating them have accumulated during long periods, and since the waters always have been supplied much more rapidly than the gravels they move slowly through as well as over these from an intake along the inner edge of the coastal plain and along the washes of the streams to an outlet at a lower point nearer the coast. The underground waters then are not in any sense lake-like; they simply

fill the voids in the gravels, sands, and clays, and move at varying rates through these voids, under the impulse of gravity and pressure from a constant if varying supply received chiefly at the inner edge of the plain. This continuous movement seaward checks any tendency of the sea water to move inland. It is indeed so completely paramount that it is probable that wells sunk into the sea floor, at short distances off the coast, would at many points yield fresh water, and probably fresh-water springs discharge into the sea at numerous localities.

While the total amount of water underlying the coastal plain then is large, only a small portion of it can be made available for purposes of irrigation. Only that part which is sufficiently near to the surface to pump at a profit, say within 250 feet, or which, although found at a greater depth, will rise under artesian pressure to or near to the surface, can be utilized. Obviously this useful surface zone is most sensitive to diversions of the supply, or to any of the forms of drainage which are included in the general term 'development." No matter from what part of a reservoir the water may be drawn, the surface will be lowered; hence the fact that an enormous quantity of water is stored beneath the coastal plain has no particular bearing upon the practical aspects of the case. The amount of water within reach and the rate of its withdrawal and replenishment, not the total amount existing, are of moment to the water user. Thus in this discussion the exhaustion of the underground supplies means the lowering of the water level until the cost of pumping absorbs all the profits from the crops raised and so becomes prohibitive.

With the original ground-water level and the original outlines of the artesian basin in the Downey and Las Bolsas quadrangles, there was but little if any of the valley or mesa land which did not have water within easy reach. With the shrinkage of the artesian belt, a broad zone along the north edge of the Downey quadrangle in which water originally flowed, was thrown into the pumping zone. Water here now has to be lifted and there is a tendency to complain because of the increased cost and trouble of this method. The general effect is excellent, however, because there are few artesian wells which are not misused. This cheap form of water induces carelessness, almost invariably more water is applied than is needed, and the result is not only a loss of water but injury to the land. With the more costly pumped water, greater care is exercised in its application. It may be stated, then, that throughout the zone originally artesian, but no longer so, a marked saving has been effected in the amount of water used, even where the acreage under irrigation has not diminished.

The rate of the general lowering of the water plane throughout the central coastal plain belt and the accompanying contraction of the artesian area have of course been accelerated by the series of dry years from 1893 to 1900, and by the moderate rainfall slightly below the average since. In consideration of the fact that all of the changes in natural conditions which are due to man's use of water have tended to reduce the supply and so to disturb the balance, of which the original artesian outlines and the original ground-water level were the expression, it must be concluded that a part at least of this lowering and contraction is due to development and is permanent.

Furthermore, so long as the new developments result in adding to the amount of water produced in a given area, the decline must continue. With the decline, springs decrease in yield or cease to flow, artesian wells fall off in output, and pumping plants are used more sparingly, because the water has become more expensive, so that finally the decrease in the amount of water secured by these means reduces the output to an equality with the supply. Then a new balance is reached, and the water level no longer falls. The point at which this new balance is reached depends upon the amount of development. The greater this amount the lower the water level will fall.

The rate of this lowering, even under the influence of the great development which has taken place in the coastal plain, especially within the last decade, has been very slow, even during the dry years, and will be still slower during years of average rainfall, because the body of water drawn upon is so great and the accessions from floods and return waters so nearly balance the withdrawals. It will not continue indefinitely if development ceases now, because the drafts decrease as the water plane lowers and the artesian area shrinks, and probably in part because with the drainage of the gravels the absorptive capacity is increased, so that a smaller proportion of the occasional floods escapes over them to the sea. But the shrinkage which is now in progress and which is expected to continue intermittently for some years, being interrupted by periods of partial restoration during winters of unusual rainfall, does not affect all parts of the coastal plain alike. Always those parts of an artesian belt which lie nearest its lower edge are affected last and least by the shrinkage. Wells will continue to flow here after they have ceased elsewhere, and pressures will be maintained here after they have seriously diminished at other points. It is probable that in so large a basin as that of the coastal plain some of these most favorably located wells will never cease to flow.

The favored places for tapping the ordinary ground waters are not distributed exactly as are those for tapping waters under pressure. Ground water will always be found near the surface, just above the upper edge of an artesian area, but in addition it is not infrequently found within easy reach near the source of supply for a basin, as just below the Paso de Bartolo, while the decline is greatest in some intermediate region. If ground water remains close to the surface near the intake of a basin, while its levels are generally lower in other localities, it is because there is some obstruction below the body of ground water which holds up the percolating moisture for a time. Such an obstruction may be a bed-rock shelf, extending out from near-by bed-rock hills, or it may be only a body of fine clay or dense alluvium.

Declines will likewise be greater in the immediate vicinity of developments, unless those developments are along a line of strong underground flowage, in which case the effect of intercepting this flowage may be more marked at some point below, which is supplied by it, than in the immediate neighborhood of the intercepting wells. In the relatively fine sands and gravels of the coastal plain, however, through which the water probably percolates ordinarily at a rate of less than 25 feet per day, the effect of a battery of pumps must be to draw out the near-by water more rapidly than it is replaced by the slow inflow and thus to lower the water plane locally to a marked degree. With the cessation of pumping, this zone is filled again by infiltration from the surrounding saturated gravels, the effect being finally to spread the depression in the water plane over an area so wide that it is no longer measurable.

A continuous series of observations upon the fluctuations in the ground-water level has not been maintained at any point in the area under discussion, but at Anaheim, a few miles east, systematic records have been kept since February, 1898, by Mr. J. B. Neff. These are of great value for comparison with rainfall records, and when so compared throw much light upon the relative importance of development and drought in bringing about the decline in water levels which has been so generally observed throughout southern California during the past decade.

*Rainfall, in inches, at Anaheim, Cal.*

| Year. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1878-79 | 0.00 | 0.00 | 0.00 | 0.15 | Tr. | 0.95 | 1.96 | 0.57 | 0.35 | 0.37 | Tr. | 0.00 | 4.35 |
| 1879-80 | .00 | .00 | .00 | .11 | 1.72 | 3.10 | 1.29 | 1.32 | 1.57 | 2.20 | 0.00 | .00 | 11.31 |
| 1880-81 | .00 | .00 | .00 | .28 | .44 | 4.92 | .25 | .28 | .85 | .06 | .00 | .00 | 7.08 |
| 1881-82 | .00 | .00 | .00 | .81 | .34 | .37 | .40 | 1.90 | 2.42 | .48 | .40 | .00 | 7.12 |
| 1882-83 | .00 | .00 | .00 | .26 | .78 | .00 | 1.48 | 1.98 | 1.22 | .10 | 2.78 | .00 | 8.60 |
| 1883-84 | .00 | Tr. | .00 | 1.12 | .00 | 1.40 | 2.80 | 10.58 | 6.70 | 1.75 | .54 | 1.28 | 26.17 |
| 1884-85 | .00 | .00 | .00 | .15 | .64 | 3.72 | .61 | .00 | .00 | .64 | .00 | .00 | 5.76 |
| 1885-86 | .00 | .00 | .00 | Tr. | 2.93 | 1.16 | 4.63 | .82 | 2.70 | 2.51 | .00 | .00 | 14.75 |
| 1886-87 | .00 | Tr. | .00 | .00 | .33 | Tr. | .43 | 5.71 | .00 | 2.21 | Tr. | .00 | 8.68 |
| 1887-88 | .00 | .00 | Tr. | .75 | .92 | 2.16 | 6.29 | .92 | 5.90 | Tr. | .00 | .00 | 16.94 |
| 1888-89 | Tr. | .00 | .00 | Tr. | 3.75 | 4.19 | .14 | 1.28 | 7.97 | .24 | .57 | .00 | 18.14 |
| 1889-90 | .00 | Tr. | .76 | 2.31 | .30 | 10.95 | 3.36 | 1.54 | .78 | .00 | Tr. | .00 | 20.00 |
| 1890-91 | .00 | .00 | .29 | .00 | .19 | 3.36 | .24 | 9.05 | .59 | 1.81 | .40 | .00 | 15.93 |
| 1891-92 | .00 | .00 | .00 | .00 | .00 | 1.44 | .77 | 2.35 | 1.23 | .15 | 1.48 | .00 | 7.42 |
| 1892-93 | .00 | .00 | .00 | .19 | .94 | 1.48 | 2.98 | 2.06 | 6.07 | .23 | .00 | .00 | 13.95 |
| 1893-94 | .00 | .00 | .00 | .00 | .30 | 2.38 | .68 | .35 | .48 | .13 | .10 | .00 | 4.42 |
| 1894-95 | Tr. | Tr. | .10 | .00 | .00 | 5.69 | 6.92 | .68 | 2.63 | .05 | .10 | .00 | 16.07 |
| 1895-96 | .00 | .00 | .00 | .00 | .97 | .48 | 3.25 | .00 | 3.03 | Tr. | .00 | .00 | 7.73 |
| 1896-97 | .00 | .00 | .00 | 1.98 | 1.40 | 1.59 | 3.00 | 4.35 | 2.20 | .00 | .00 | .00 | 14.52 |
| 1897-98 | .00 | .00 | .10 | 1.60 | .00 | .00 | 1.65 | .10 | 1.00 | .20 | 1.00 | .00 | 5.65 |
| 1898-99 | .00 | .00 | Tr. | .00 | .00 | .20 | 2.78 | .15 | 1.61 | .20 | .00 | .51 | 5.25 |
| 1899-1900 | .00 | .00 | .07 | 1.32 | .84 | 1.45 | 1.29 | .00 | .73 | 1.09 | 1.49 | .09 | 8.37 |
| 1900-1901 | .00 | .00 | .00 | .34 | 4.81 | .00 | 3.50 | 3.11 | .59 | Tr. | 2.30 | .00 | 14.65 |
| 1901-2 | .00 | .00 | .00 | 1.34 | .50 | .00 | 1.70 | 3.16 | 3.20 | .11 | .07 | Tr. | 10.08 |
| 1902-3 | Tr. | .00 | .00 | .40 | 1.36 | 3.83 | 1.22 | 2.61 | 5.58 | 4.47 | .00 | .00 | 19.47 |
| 1903-4 | .00 | .00 | .38 | .06 | .00 | .00 | .19 | 1.39 | 3.61 | .82 | (?) | .00 | 6.45 |

Average, twenty-six years, 11.45 inches.

The Anaheim records have been discussed in an earlier paper;[a] but as the conclusions to be drawn from them are of general interest, a résumé of the discussion is repeated here.

For purposes of comparison with Mr. Neff's profile, the rainfall records at Anaheim and Los Angeles have been plotted in such a way as to bring out particularly the departures from the average at each of these places. At Anaheim rainfall records covering a period of twenty-six years are available, and the average for this time has been 11.45 inches. At Los Angeles records have been kept for twenty-seven years, and the average is 15.35 inches. The San

[a] Water-Sup. and Irr. Paper No. 137, U. S. Geol. Survey.

Bernardino average for thirty-four years is 15.06 inches. In the charts which have been prepared these averages are selected as base lines, and the amount of rainfall in excess of the average for any

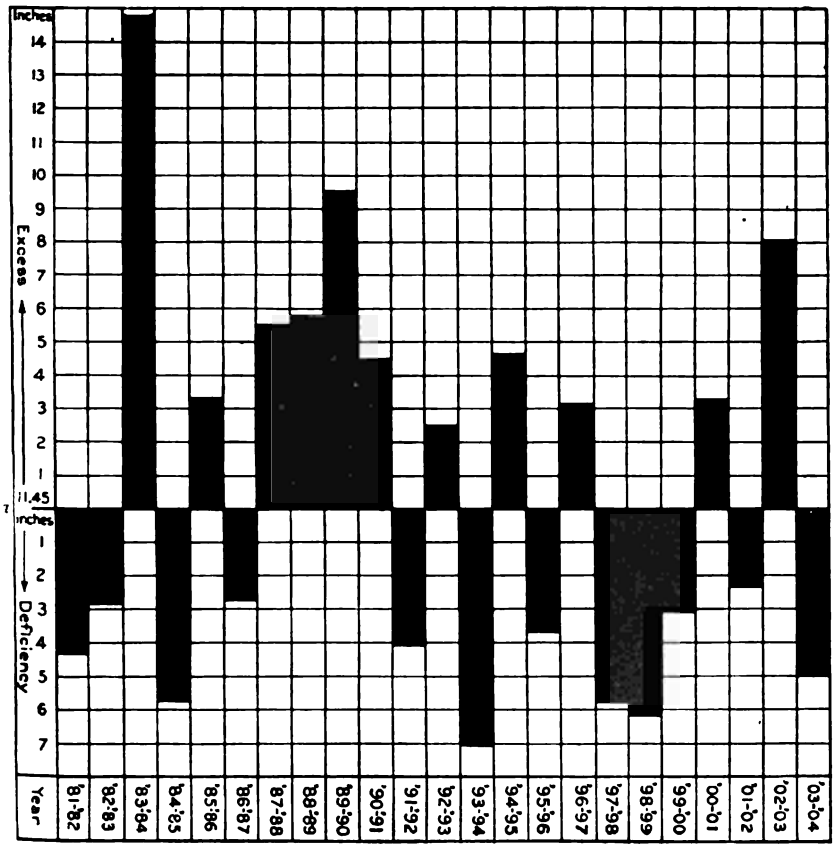


FIG. 1.—Chart showing departures from average rainfall at Anaheim, Cal. a Average for 26 years (11.45 inches).

year is plotted above this base, and the deficiency for any year below it. Thus one sees at a glance what years are years of excessive rainfall and what are years of deficiency.

*Rainfall, in inches, at San Bernardino, Cal.*

| Year. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1870-71 | 0.00 | 0.00 | 0.02 | 0.09 | 3.11 | 0.89 | 6.91 | 2.21 | 0.19 | 0.34 | 0.11 | 0.07 | 13.94 |
| 1871-72 | .00 | .04 | .13 | .60 | .88 | 3.91 | .00 | 2.20 | .37 | .79 | .06 | .00 | 8.98 |
| 1872-73 | .00 | .18 | .04 | .00 | 1.17 | 4.40 | 6.50 | 1.25 | .51 | .84 | .21 | .00 | 15.10 |
| 1873-74 | .00 | 1.06 | .02 | .01 | .74 | 5.73 | 5.51 | 8.76 | 1.08 | .48 | .42 | .00 | 23.81 |
| 1874-75 | .00 | .00 | .06 | 1.82 | 1.88 | 2.20 | 7.20 | .15 | .22 | .07 | .05 | .00 | 13.65 |
| 1875-76 | .00 | .00 | .00 | .00 | 7.50 | .02 | 6.55 | 1.92 | 3.41 | .44 | .03 | .03 | 19.90 |
| 1876-77 | .00 | .00 | .00 | .20 | .40 | .00 | 3.50 | 4.03 | .83 | .26 | .30 | .00 | 9.52 |
| 1877-78 | .00 | .00 | .00 | .86 | .50 | 3.95 | 3.33 | 6.68 | 2.57 | 1.71 | .66 | .07 | 20.33 |
| 1878-79 | .07 | .00 | .02 | .14 | .05 | 4.70 | 3.59 | 1.00 | .50 | 1.20 | .24 | .03 | 11.54 |
| 1879-80 | .11 | .02 | .01 | .94 | 3.40 | 6.50 | 1.56 | 1.33 | 1.45 | 5.00 | .04 | .00 | 20.36 |
| 1880-81 | .00 | .00 | .00 | .14 | .67 | 8.80 | 1.40 | .36 | 1.66 | .46 | .01 | .00 | 13.50 |
| 1881-82 | .00 | .00 | .00 | .80 | .27 | .50 | 1.11 | 2.65 | 3.30 | 2.91 | .00 | .00 | 11.54 |
| 1882-83 | .00 | .00 | .00 | .10 | .15 | .45 | 1.60 | 1.10 | 2.82 | 2.95 | .00 | .00 | 9.17 |
| 1883-84 | .19 | .00 | .53 | .85 | .09 | 2.63 | 1.63 | 12.20 | 9.95 | 5.68 | 3.17 | .59 | 37.51 |
| 1884-85 | .00 | .00 | .00 | .00 | .11 | 3.75 | 2.79 | .11 | .28 | 1.89 | 1.69 | .19 | 10.81 |
| 1885-86 | .00 | .00 | .00 | .39 | 4.36 | 1.20 | 6.34 | 2.52 | 4.18 | 2.36 | .32 | .16 | 21.83 |
| 1886-87 | .00 | .00 | .00 | .00 | .11 | .61 | .39 | 6.44 | 4.41 | 1.90 | .42 | .22 | 14.50 |
| 1887-88 | .11 | .04 | .09 | 1.17 | 2.29 | 1.91 | 4.01 | 3.60 | 3.41 | .58 | .52 | .03 | 17.76 |
| 1888-89 | .00 | .00 | .00 | .05 | 4.12 | 4.64 | .93 | 1.50 | 6.55 | 2.05 | 1.13 | .00 | 20.97 |
| 1889-90 | .17 | .63 | .11 | 2.30 | 2.23 | 10.85 | 5.44 | 2.52 | .80 | .00 | .31 | .00 | 25.45 |
| 1890-91 | .13 | 2.16 | .88 | .58 | 1.27 | 3.02 | .00 | 7.78 | .06 | .53 | 1.67 | .00 | 18.08 |
| 1891-92 | .00 | .91 | .93 | Tr. | Tr. | 1.67 | 3.24 | 3.30 | 1.75 | .37 | 2.10 | .08 | 14.35 |
| 1892-93 | .00 | .00 | .00 | .16 | 1.02 | 2.23 | 4.53 | 3.37 | 8.00 | .48 | .03 | .00 | 19.82 |
| 1893-94 | .20 | .00 | .05 | 1.05 | .30 | 2.28 | 1.26 | .88 | 1.15 | .40 | .56 | .00 | 8.13 |
| 1894-95 | .00 | .16 | .37 | .15 | .00 | 7.25 | 7.39 | 1.14 | 3.44 | .64 | .44 | .00 | 20.98 |
| 1895-96 | .00 | .00 | .00 | .00 | 1.14 | .66 | 2.02 | .00 | 2.92 | .37 | 1.00 | .00 | 8.11 |
| 1896-97 | Tr. | .17 | .00 | 2.10 | .98 | 1.09 | 3.40 | 5.40 | 3.41 | .08 | .11 | .00 | 16.74 |
| 1897-98 | Tr. | .00 | .13 | 2.10 | .21 | .57 | 2.10 | .60 | .97 | .48 | 1.08 | .00 | 8.24 |
| 1898-99 | .00 | .00 | .00 | .03 | .05 | .44 | 2.03 | .51 | 3.22 | .07 | .19 | .95 | 7.49 |
| 1899-1900 | .00 | Tr. | .01 | .81 | 1.47 | .84 | .92 | .00 | .92 | 1.96 | 1.71 | .00 | 8.64 |
| 1900-1901 | .34 | .00 | .23 | .36 | 6.10 | .00 | 3.48 | 4.58 | .43 | .56 | 1.23 | .05 | 17.36 |
| 1901-2 | .00 | .27 | .07 | 1.09 | .28 | .04 | 1.65 | 3.02 | 3.89 | .57 | .12 | .15 | 11.15 |
| 1902-3 | .01 | .00 | .00 | .09 | 1.94 | 1.94 | 1.96 | 1.67 | 6.47 | 3.10 | .24 | .00 | 17.42 |
| 1903-4 | .00 | .15 | .46 | .07 | .00 | .00 | .18 | 2.21 | 5.34 | .80 | .16 | .00 | 9.37 |

Average, thirty-four years, 15.06 inches.

Since the rainfall which is most efficient in supplying the surface and subsurface waters of the coastal plain is that which falls in the mountains in which Los Angeles, San Gabriel, and Santa Ana rivers rise, the Los Angeles and the San Bernardino rainfall charts are of more value for purposes of comparison with the profile of the water level than the Anaheim record, which indicates coastal conditions.

Each of these records shows that during the past eleven rainy seasons there has been a marked deficiency. For seven of the eleven this deficiency aggregates about 52 inches at Los Angeles and

about 45 inches at San Bernardino, while the other four years give excessive precipitations of 12 inches at San Bernardino and 7 inches

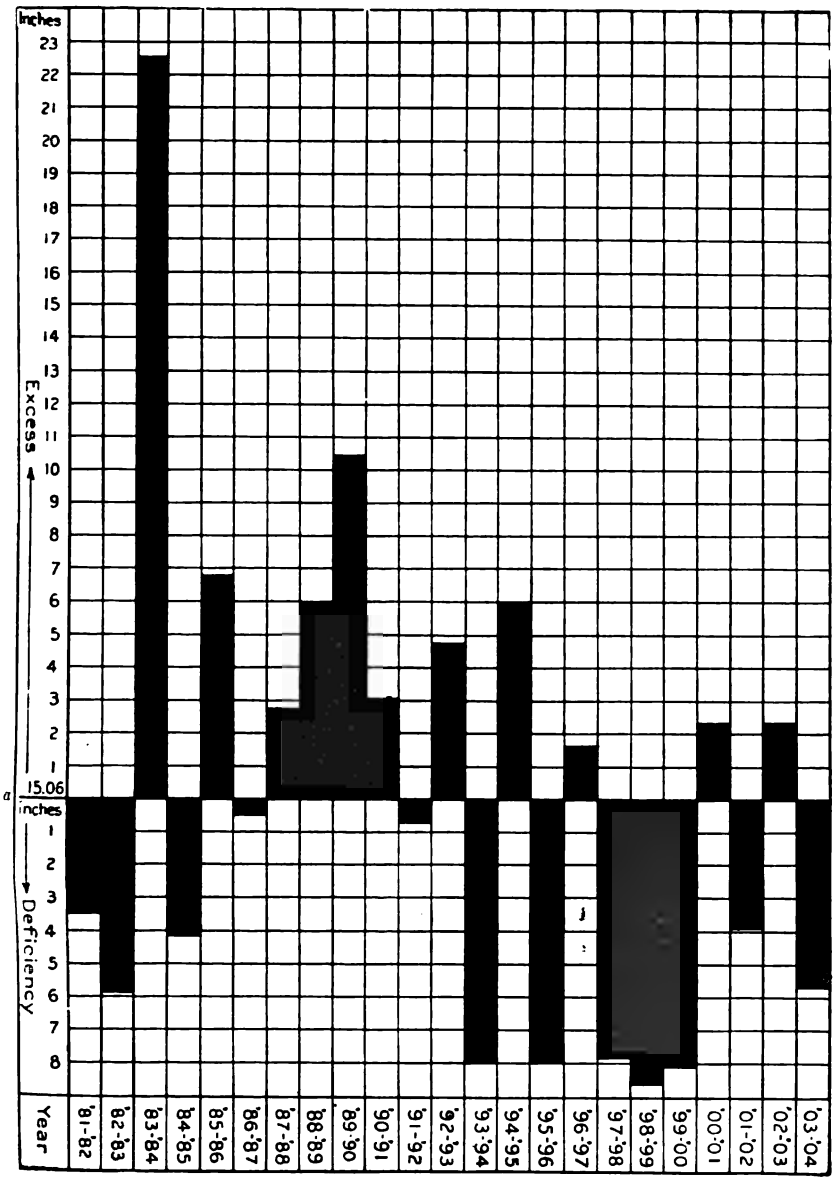


FIG. 2.—Chart showing departures from average rainfall at San Bernardino, Cal. a Average for 34 years (15.06 inches).

at Los Angeles. The average deficiency during the period, therefore, has been about 26 per cent at Los Angeles, 20 per cent at San

Bernardino, and 11 per cent at Anaheim. So marked a falling off in rainfall is in itself sufficient to account for much shrinkage in the ground waters, hence a general decline in water levels is not surprising.

*Rainfall, in inches, at Los Angeles, Cal.*

| Year. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1877-78 | 0.00 | 0.00 | 0.00 | 0.86 | 0.45 | 3.93 | 3.33 | 7.68 | 2.57 | 1.71 | 0.66 | 0.07 | 21.26 |
| 1878-79 | ·00 | Tr. | .00 | .14 | Tr. | 4.70 | 3.59 | .97 | .49 | 1.19 | .24 | .03 | 11.35 |
| 1879-80 | .00 | .00 | .00 | .93 | 3.44 | 6.53 | 1.33 | 1.56 | 1.45 | 5.06 | .04 | .00 | 20.34 |
| 1880-81 | Tr. | Tr. | .00 | .14 | .67 | 8.40 | 1.43 | .36 | 1.66 | .46 | .01 | .00 | 13.13 |
| 1881-82 | .00 | Tr. | Tr. | .82 | .27 | .52 | 1.01 | 2.66 | 2.66 | 1.83 | .63 | Tr. | 10.40 |
| 1882-83 | .00 | .00 | Tr. | .05 | 1.82 | .08 | 1.62 | 3.47 | 2.87 | .15 | 2.02 | .03 | 12.11 |
| 1883-84 | Tr. | .00 | .00 | 1.42 | .00 | 2.56 | 3.15 | 13.37 | 12.36 | 3.54 | .34 | 1.39 | 38.13 |
| 1884-85 | Tr. | Tr. | Tr. | .30 | 1.06 | 4.64 | 1.05 | Tr. | .01 | 2.00 | .06 | Tr. | 9.12 |
| 1885-86 | Tr. | Tr. | Tr. | .26 | 5.52 | 1.63 | 7.72 | 1.38 | 2.50 | 3.29 | .00 | .01 | 22.31 |
| 1886-87 | .24 | .21 | .00 | .01 | 1.18 | .18 | .20 | 9.25 | .24 | 2.30 | .20 | .04 | 14.05 |
| 1887-88 | .07 | .00 | .15 | .12 | .78 | 2.67 | 6.03 | .77 | 3.15 | .11 | .02 | Tr. | 13.87 |
| 1888-89 | .03 | .08 | Tr. | .36 | 4.01 | 6.26 | .25 | .92 | 6.48 | .27 | .62 | .00 | 19.28 |
| 1889-90 | .00 | .61 | .0 | 6.95 | 1.35 | 15.80 | 7.83 | 1.36 | .66 | .22 | .03 | .02 | 34.83 |
| 1890-91 | .0 | .03 | .06 | .03 | .13 | 2.32 | .25 | 8.56 | .41 | .26 | .31 | .00 | 12.36 |
| 1891-92 | Tr. | .00 | .06 | .00 | .00 | 1.99 | .88 | 3.19 | 3.39 | .22 | 2.06 | .06 | 11.85 |
| 1892-93 | .00 | .01 | .00 | .33 | 4.40 | 4.18 | 6.29 | 2.27 | 8.52 | .19 | .06 | .03 | 26.28 |
| 1893-94 | .00 | .00 | Tr. | .75 | .20 | 3.65 | .94 | .49 | .37 | .13 | .20 | Tr. | 6.73 |
| 1894-95 | Tr. | .01 | .73 | .02 | .00 | 4.62 | 5.84 | .46 | 3.77 | .46 | .19 | .01 | 16.11 |
| 1895-96 | Tr. | Tr. | Tr. | .24 | .80 | .78 | 3.23 | Tr. | 2.97 | .19 | .30 | Tr. | 8.51 |
| 1896-97 | .02 | .01 | Tr. | 1.30 | 1.66 | 2.12 | 3.70 | 5.62 | 2.31 | .02 | .10 | Tr. | 16.86 |
| 1897-98 | Tr. | .00 | .00 | 2.47 | .01 | .05 | 1.26 | .51 | .98 | .03 | 1.75 | Tr. | 7.06 |
| 1898-99 | .07 | Tr. | .02 | .00 | Tr. | .12 | 2.64 | .04 | 1.81 | .18 | .04 | .58 | 5.59 |
| 1899-1900 | .00 | .01 | Tr. | 1.59 | .90 | .90 | 1.17 | Tr. | .99 | .54 | 1.81 | Tr. | 7.91 |
| 1900-1901 | Tr. | Tr. | Tr. | .26 | 6.53 | Tr. | 2.49 | 4.38 | .45 | .68 | 1.50 | Tr. | 16.29 |
| 1901-2 | Tr. | .09 | .03 | 1.88 | .46 | Tr. | 1.62 | 3.35 | 2.98 | .16 | .03 | Tr. | 10.60 |
| 1902-3 | Tr. | Tr. | Tr. | .40 | 2.08 | 2.50 | 2.10 | 1.52 | 6.93 | 3.77 | Tr. | .02 | 19.32 |
| 1903-4 | .00 | Tr. | .43 | Tr. | .00 | Tr. | .14 | 2.68 | 4.50 | .97 | Tr. | Tr. | 8.72 |

Average, twenty-seven years, 15.35 inches.

A close examination of the Anaheim profile shows that the decline was steady and uninterrupted during the three very dry years which preceded and included the winter of 1899–1900. The succeeding winter was one in which the rainfall at Anaheim, at Los Angeles, and at San Bernardino was somewhat in excess of the normal, the excess varying from 9 per cent at Los Angeles to 28 per cent at Anaheim.

During the early part of the winter of 1901 the Anaheim profile shows a sharp rise in the water level, the gain during the first three months of the year being approximately 2 feet, but by the middle of the succeeding August the water had fallen again to a lower level than it had reached at any time before this winter, whose rainfall exceeded the normal.

In short, the decline continued during a winter of excessive rainfall. Throughout the season of 1901–2 also it continued, but as this again was a winter of marked deficiency, a loss was to be expected.

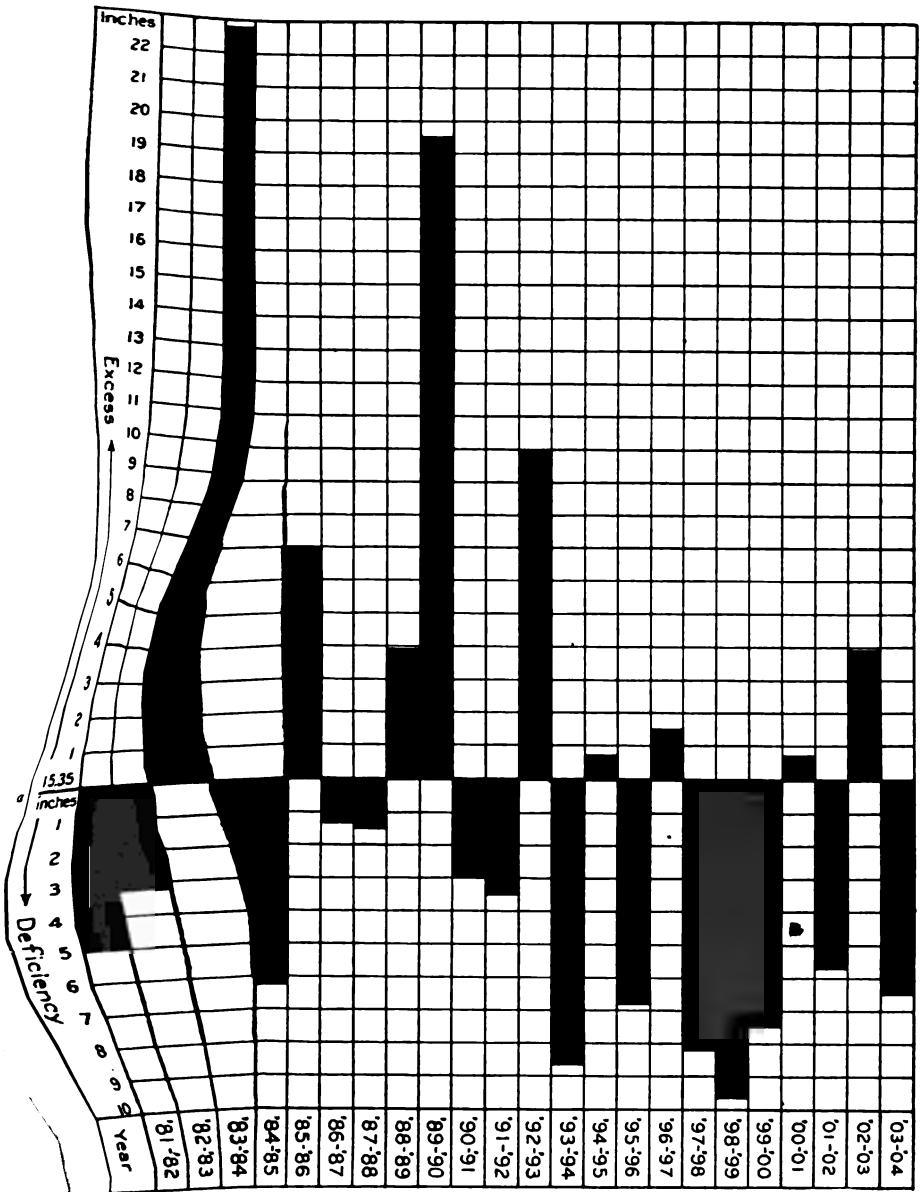


FIG. 3.—Chart showing departures from average rainfall at Los Angeles, Cal. *a*, average for 27 years (15.35 inches).

But the season of 1902–3 was again a winter of rainfall in excess. This excess amounted to about 15 per cent of the normal at San Bernardino, about 70 per cent at Anaheim, and about 22 per cent at

Los Angeles. The effect upon the Anaheim water level, while less marked than that of the heavy rainfall two years before, was more last ng, the rise of April and May, 1903, not being wholly lost until January 1, 1904. Since that time there has been no heavy rainfall and the decline has been continuous.

The important point in this comparison is the fact that the water level has continued to decline during two years of marked excess in precipitation. This fact seems to point unmistakably to excessive drafts upon the underground waters in the region to which it applies.

Direct observations of this kind have not been made in the Downey quadrangle, where there are only the general phenomena of decline

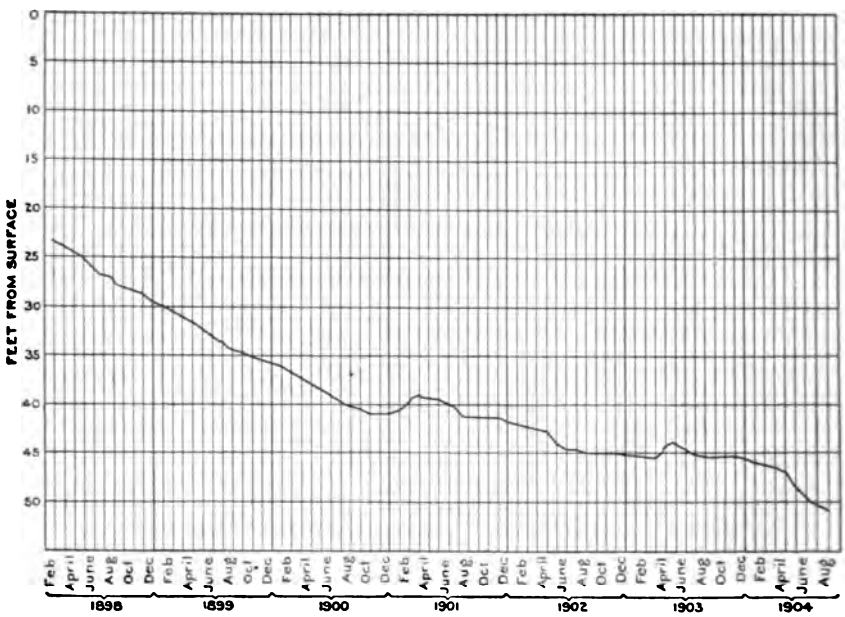


FIG. 4.—Diagram showing variation of water level near Anaheim, Cal.

from which to draw conclusions. The artesian area exhibits as marked shrinkage in the Downey as in the Anaheim region, and it is known that ground-water levels have fallen there markedly. There are more artesian wells but fewer pumping plants. Since the yield of flowing wells is very sensitive to the fluctuations in the ground-water levels and to the accompanying changes in pressure, while the output of pumped wells responds much less freely to these variations, pumping may be considered the more efficient agent in reducing the supply. So as yet the conditions at Anaheim are thought to be extreme rather than general. The unlimited extension of developments, however, may soon result in their becoming general.

## SUMMARY.

The discussion and conclusions as to the underground water supply in the central coastal plain region may be summarized thus:

(*a*) The supply is large, since it consists of the water saturating all of that part of the coastal plain gravels within pumping distance, say 250 feet from the surface, over an area of 600 or 700 square miles.

(*b*) The annual additions to the supply are large, consisting of a part of the flood waters of the San Gabriel, Los Angeles, and Santa Ana rivers, of the return waters from irrigation on the coastal plain, of the relatively small underflow of the rivers named, and of local rainfall upon this part of the coastal plain and the adjacent hills.

(*c*) The drafts upon these waters are large and seem certainly to be in excess of the supply in parts of the area at present.

(*d*) With present developments the water plane is expected to continue slowly to decline, and the artesian area to shrink until drainage is checked by these shrinkages at a point where it no longer exceeds supply. This decline should not prove serious *if present developments are not greatly increased.*

(*e*) So long as water developments continue at a rate which increases the output the shrinkage will continue.

(*f*) The lowering of the ground-water level and the shrinkage of artesian areas, even with continued development, will no doubt be interrupted by periods of rising water levels and expanding artesian areas, which will follow seasons of excessive rainfall.

(*g*) The shrinkage of the artesian belt will be most manifest along its northern edge. The effect farther south will be rather a decrease of flow and a lessening of pressure.

(*h*) Shallow artesian wells will generally be affected earlier and to a more marked extent than deeper ones.

## DESCRIPTION OF MAPS AND TABLES.

The maps in this paper show the lands irrigated in 1903–4, the irrigation canals, all of which head in or near the Paso de Bartolo, the present and the original artesian basins, and the location of wells, artesian, pumped, or domestic, in the Downey and Las Bolsas quadrangles (Pls. I, II, and IV).

The irrigated lands and those not irrigated are less clearly differentiated in the naturally more or less moist lands of the lower parts of the coastal plain than on the dry mesa and bench lands, and irrigation practice is often vague and unsystematic there. In many cases winter irrigation is practiced, the waters of the San Gabriel reaching the lower stretches of the river channel or the lower ditches only at this season, when water is abundant. It is then used to augment the rainfall on pasture lands. Irrigation of this type is

included in our classification of irrigated lands. The total area under irrigation in the Downey and Las Bolsas quadrangles is nearly 45,000 acres, or about 25 per cent of the total area.

The map of the artesian basin, past and present (Pl. I), is self-explanatory. It is to be said, however, that the boundaries differ for wells of differing depth, since deep wells may flow when they are some distance farther north than shallower wells that have ceased to flow.

As the limits have been drawn on the maps they include within the artesian area all wells flowing at the time the data were collected in the summer of 1903 and the succeeding winter. After a very wet year the northern boundary of the present artesian area may shift to the north; with average rainfall and continued development it will probably shift to the south. The southern limit should show but little change.

Outside of the artesian basin the ground-water level has been shown by hydrographic contours (Pl. I). These are lines showing the elevation of the surface of the plane of saturation. The depth to ground water at any point is determined by finding the difference between the elevations indicated by the topographic contours and those indicated by the hydrographic contours. The line of hills which forms the southern limit of the artesian basin follows a zone in which the water levels are so irregular that it was not practicable to extend the hydrographic contours across it.

Three kinds of symbols are used to indicate wells that flow, wells at which pumping plants have been installed, and the small windmill and domestic wells. Thus the map shows approximately the artesian belt and the areas of greatest development by pumping. Both artesian wells and pumping plants are constantly increasing, and by the time this report is ready for distribution many more will exist than are shown on the map, although this list was nearly complete for artesian wells and pumping plants at the time the field work was finished, in the spring of 1904. Many of the small domestic wells have not been examined and do not appear in the lists. Each well visited has been located on the map and numbered there. The information collected concerning it appears in the tables opposite this number. The information includes the name of the owner, the rancho, or, if on public land surveys, the town, range, and section, the date of completion, the size and depth of the well, the depth of water and the elevation of its surface, the approximate amount of dissolved solids in parts per 100,000, the method used in raising the water, the approximate cost of the well and of the machinery installed, and the amount of water secured. The greater part of this information was obtained from the owner of the well, data as to cost being in all cases supplied by him. The

depths of shallower wells that were accessible were measured. If the well is more than 300 feet deep, or was capped or otherwise closed, the owner's statement was taken or the driller's record consulted.

In a great many cases it was necessary also to accept the owner's statement as to the output of his well. This was particularly true of the pumping plants. Artesian wells could much more often be measured, and in every case where it was possible determinations of output were made, whether the water was artesian or pumped. Owners' statements are usually excessive.

The purity of the water was rapidly and approximately determined in the field with an electrolytic bridge, the method being based upon the fact that a definite relation exists between the amount of dissolved solids in the waters and the electrical resistance. The degree of accuracy attained in this work is probably somewhat less for the Downey quadrangle than for the Las Bolsas quadrangle, which was examined at a cooler season, as high temperatures affect the accuracy of the method. It is hoped, however, that the tests are correct within five or six parts per 100,000 in nearly all cases and that their usual accuracy is much closer than this. The results are tabulated with the other data about the wells and have also been assembled on a map (fig. 5) on which the underground waters have been classified upon the basis of their alkalinity, and on which the distribution of the broader zones is shown. Such a map furnishes general evidence as to the course of the underground circulation, and in this case indicates that the waters which come out through the Paso de Bartolo spread into a broad stream, unite with those of the Los Angeles and Santa Ana systems, and seek an outlet to the ocean in the region between Los Alamito Beach and Newport Beach. The preparation of this map showed that shallow wells, even in the areas of generally pure water, often contain very notable amounts of alkalies and that the deeper wells generally carry a smaller proportion of salts than the shallower ones. The zones, as they have been mapped, represent the general condition of waters drawn from sufficient depth to be free from surface contamination. They illustrate well the effect of the run-off from the shale hills upon the waters in the adjacent lowlands, and show also the greater purity of the ground waters in the zones of freest underground circulation, as between the passes by which the greater streams reach the coastal plain and the seashore. They illustrate, too, the somewhat inferior quality of those ground waters which lie upon the seaward side of the ridge which limits the artesian basin on the southwest. These waters, it is to be said, are irregular in their alkalinity, near-by wells often exhibiting considerable d fferences in the quantity of dissolved salts. Within the lower parts of the

artesian basin, on the contrary, the waters are very uniform in quality and contain but little mineral matter.

The waters of several of the deep wells of the Downey quadrangle are more or less impregnated with sulphureted hydrogen, and some of them are stained brown, probably by vegetable matter, peaty in character, which has been buried as the sands and gravels have accumulated. The subterranean waters in contact with these peaty beds are colored just as surface waters in contact with vegetable matter in swamps or marshes become stained. These gaseous

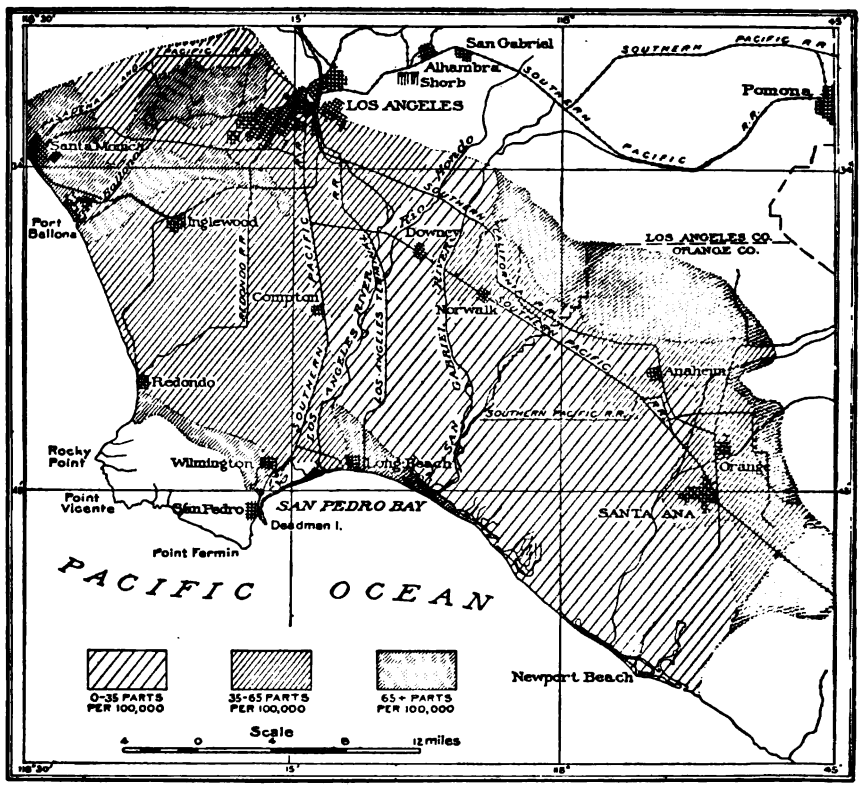


FIG. 5.—Map showing approximate amounts of dissolved solids in underground waters of coastal plain region of southern California.

and organic elements affect the electrical resistance but little, if at all, and therefore do not appear in the tabulated and mapped results.

## ACKNOWLEDGMENTS.

Much the greater part of the work of collecting the information in the field concerning wells and water levels on the Downey quadrangle was done by Messrs. A. C. Hansen and E. R. Furstenfeld, who also mapped the irrigated lands. Mr. W. N. White is chiefly responsible for the field work in the Las Bolsas quadrangle. The

task of tabulating the results of the field work and preparing maps and tables for publication has fallen principally upon Messrs. A. J. Fisk, jr., and W. N. White.

Acknowledgments are due also to the well owners and water companies who have responded to queries and have thereby enabled the data to be procured.

The work which has resulted in the collection of this material was originally planned and inaugurated by Messrs. J. B. Lippincott and Homer Hamlin, engineers of the Reclamation Service. The credit for its initiation is theirs exclusively, and except that the increasing pressure of the important work of the Reclamation Service has come to claim more and more of their energies this work would probably have been carried out to completion under their direction.

## WELL DATA.

*Wells in the Downey quadrangle.*

[* Cost of well and equipment combined; † yield estimated or statement of owner taken; ? doubtful. The miner's inch used in these tables is the old California miner's inch, i. e., the amount of water which flows from a 1-inch orifice under a 4-inch head; it is equal to 9 gallons per minute, 14,478 acre-feet per year or one-fiftieth second-foot.]

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1 | J. H. Dutcher | San Antonio | A-1 | 1903 | Bored, 10-inch | 173 | 135 | 115 | | | $175.00 | | Irrigation | |
| 2 | J. A. Gar | do | A-2 | 1895 | Bored, 7-inch | 169 | 133 | 69 | 59 | Wind | 70.00 | $175.00 | Domestic | |
| 3 | F. Ahrens | do | A-2 | 1898 | Bored, 10-inch | 176 | 132? | 100 | 61 | | 140.00 | | Irrigation | 60 |
| 4 | Z. S. Spaulding | do | A-2 | 1898 | do | 174 | 144? | 100 | | Propeller pump. | 150.00 | 1,250.00 | do | 90 |
| 5 | A. B. Merrill | do | A-2 | 1889 | Bored, 7-inch | 174 | 133 | 55 | | Wind | 65.00 | 75.00 | Domestic; irrigation. | 1½ |
| 6 | C. Dutcher | do | A-2 | 1897 | do | 167 | 129? | 100 | | Electric motor | 115.00 | 1,200.00 | Irrigation | 100 |
| 7 | J. H. Dutcher | do | A-2 | 1895 | Bored, 8-inch | 162 | 133 | 104 | 65 | do | 175.00 | 1,200.00 | do | 80 |
| 8 | Chas. Gillon | do | A-1 | 1900 | Bored, 10-inch | 175 | 135 | 87 | | Electricity | 300.00 | 1,500.00 | do | 135 |
| 9 | Mrs. M. J. Russell | do | A-2 | 1883 | Bored, 7-inch | 156 | 131 | 87 | 68 | Hand | 90.00 | 20.00 | Domestic | |
| 10 | Geo. Logic | do | A-3 | 1900 | Bored, 3½-inch | 150 | 128 | 93 | 69 | do | 85.00 | 15.00 | do | |
| 11 | Mrs. Sarah Braby | do | A-3 | 1883 | Bored, 7-inch | 148 | 128 | 93 | | Wind | | | do | |
| 12 | Julius Conrad | do | A-3 | 1896 | Bored, 10-inch | 146 | 129 | 480 | 30 | Gas | 600.00 | 1,000.00 | Irrigation; domestic. | 100 |
| 13 | do | do | A-3 | 1896 | Bored, 8-inch | 146 | 129 | 140 | 56 | do | 125.00 | | do | |
| 14 | Annette Thaxter | do | A-3 | 1876 | do | 142 | 128 | 111 | 54 | Wind | 150.00 | 175.00 | Domestic | |
| 15 | Geo. Nadeau | do | A-3 | 1883 | Bored, 7-inch | 144 | 124 | 180? | 63 | do | 180.00 | 135.00 | do | |
| 17 | D. W. Moore | do | A-2 | 1902 | do | 155 | 128? | 115 | 61 | do | 118.75 | 90.00 | do | |
| 18 | Quong Lung | Los Angeles city | A-1 | 1897? | Bored, 6-inch | 185 | 138 | 54 | | do | | | do | |
| 19 | J. Inverarity | do | A-1 | 1900 | Bored, 7-inch | 188 | 137 | 60 | 52 | do | 65.00 | 200.00 | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | A. Rueff | do | A-1 | 1898 | do | 89 | 137 | 54 | 62 | do | | | do | | |
| 21 | I. Gibbs | do | A-1 | 1902 | Bored, 12 inch | 193 | 138 | 90 | 57 | Gas | 157.50 | 2,200.00 | Irrigation | 120 |
| 22 | James Haddock | do | A-1 | 1901 | Bored, 7-inch | 193 | 139 | 60 | | Wind | 65.00 | 200.00 | Domestic | 1 |
| 23 | Mrs. P. B. Hardenberg | do | A-1 | 1899? | do | 195 | 140 | 65 | 52 | do | | | do | |
| 24 | Pacific Electric Ry. Co. | do | A-1 | 1899 | do | 194 | 138 | 70 | | do | | | do | |
| 25 | Ida McClure | do | A-1 | 1882 | do | 192 | 137 | 61 | 46 | do | | | do | |
| 26 | Chas. Hull | do | A-1 | 1881 | do | 191 | 122 | 77 | 48 | do | 85.00 | 75.00 | do | |
| 27 | W. A. Ross | do | A-1 | 1902 | do | 183 | 135 | 68 | 38 | do | 56.00 | 152.00 | do | |
| 28 | Burbank & Baker | San Antonio | A-2 | 1902 | Bored, 10-inch | 180 | 135 | 91 | 45 | Gas | | | Irrigation; domestic. | 50 |
| 29 | Estavan Herrera | do | A-2 | | Bored, 7-inch | 179 | 134 | 75 | 43 | Wind | | | Domestic | 1 |
| 30 | John B. Morrison | do | A-2 | 1901 | Bored, 10-inch | 176 | 144? | 97 | | Gas | 140.00 | 1,375.00 | Irrigation | 142 |
| 31 | I. H. Bryson | do | A-2 | 1898 | do | 171 | 133 | 92 | 30 | Electricity | 200.00 | 1,050.00 | do | 75 |
| 32 | Wm. R. Roney | do | A-2 | 1901 | do | 164 | 128 | 415 | 49 | do | 1,500.00 | 1,500.00 | do | 52 |
| 33 | T. E. Cleland | do | | 1897 | do | 156 | 126? | 260 | 42 | do | 500.00 | 1,200.00 | do | †175 |
| 34 | R. A. Innes | do | A-2 | 1901 | Bored, 7-inch | 159 | 129 | 75 | 42 | Wind | 86.00 | 170.00 | Domestic; irrigation. | 1 |
| 35 | Michael Cudahy | do | B-2 | 1899 | Bored, 12-inch | 156 | 122 | 400? | | Compressed air | 1,000.00 | 2,000.00 | Irrigation | 60 |
| 36 | do | do | B-2 | 1900 | do | 155 | 121 | 400 | 34 | do | 1,000.00 | 2,000.00 | do | 60 |
| 37 | L. Wright | do | A, B-2 | 1887 | do | 169 | 133 | 85 | 51 | Wind | | 164.00 | Domestic | 1½ |
| 38 | E. V. Baker | do | B-1 | 1902 | Bored, 10-inch | 181 | 135 | 277 | 39 | | 456.00 | | Not used | |
| 39 | Dan Cunningham | do | B-2 | 1900 | Bored, 12-inch | 170 | 134 | 400 | 45 | Compressed air | 1,000.00 | | Irrigation | 15 |
| 40 | Chas. Miles | do | B-2 | 1884 | Bored, 7-inch | 169? | 132 | 85 | 42 | Wind | | | Domestic | |
| 41 | Gail Borden | do | C-2 | 1884 | do | 153 | 126 | 91 | 40 | do | | | do | |
| 42 | do | do | B-2 | 1900 | Bored, 10-inch | 158 | 128 | 121 | 37 | | | | Irrigation | 60 |
| 43 | J. G. Bell | do | C-2 | 1899 | Bored, 12-inch, 262 feet; 9½-inch, 374 feet. | 158 | 133? | 636 | 41 | Propeller pump | | | Domestic; irrigation. | 150 |
| 44 | E.G. Greening | do | C-½ | 1902 | Dug, 3 by 3 foot | 164 | 148 | 173 | 49 | Hand | 10.00 | 6.00 | Domestic | |
| 45 | W. N. Angel | do | C-1 | 1894 | Bored, 7-inch | 177 | 142 | 112 | 44 | Wind | 125.00 | 100.00 | Domestic; irrigation. | 1½ |
| 46 | James Gillespie | do | B-1 | 1892 | do | 177 | 137 | 128 | 43 | do | 150.00 | 50.00 | Domestic | 1½ |
| 47 | G. W. Brookins | do | C-1 | 1900 | Bored, 10-inch | 179 | 148? | 135 | | Propeller pump | 200.00 | | Irrigation | 95 |
| 48 | Fruitland Water Co | do | B-1 | 1898 | Bored, 12-inch | 177 | 126 | 250 | | Compressed air | 1,000.00 | 1,700.00 | do | 50 |
| 49 | John H. Van Nest | do | C-1 | 1873 | Bored, 7-inch | 182 | 133 | 285 | 35 | Wind | | 100.00 | Domestic | |
| 50 | Steven Musante | do | C-1 | 1898 | do | 183 | 154 | 106 | 55 | do | 110.00 | 100.00 | Domestic; irrigation. | 1½ |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 51 | J. S. Quinn | San Antonio | C-1 | 1901 | Bored, 9-inch | 180 | 140 | 100 | 39 | Wind | $300.00 | | Domestic | 1½ |
| 52 | A. E. Bell | San Pedro | D-2 | 1898 | Bored, 10-inch | 148 | 136 | 1,360 | 39 | Electricity | 1,500.00 | $1,200.00 | Irrigation | 150 |
| 53 | F. F. Culver | do | B-8 | 1873? | Bored, 6-inch | 73 | 73 | 230 | | Artesian | 400.00 | | Domestic | |
| 54 | Frank Walton | do | A, B-8 | 1902 | Bored, 10-inch | 73 | 73 | 500 | 32 | do | 700.00 | | Irrigation | 1 |
| 55 | A. C. Bird | do | A-8 | 1885 | Bored, 7-inch | 82 | 82 | 170 | 33 | Wind, artesian | 150.00 | 350.00 | Domestic | 1½ |
| 56 | Mrs. Minnie Stuart | do | A-8 | 1891 | do | 84 | 81 | 160 | | Gas | | 400.00 | Irrigation | 30 |
| 57 | Mrs. H. C. Montague | do | A-8 | 1894 | do | 81 | 81 | 192 | | Artesian | 500.00 | | Not used | |
| 58 | Chas. Marble | do | A-8 | 1898 | do | 89 | | 300 | | Gas | 600.00 | 450.00 | Irrigation | 40 |
| 59 | C. A. Conklin | do | A-7 | 1896 | do | 88 | | 200 | | do | 400.00 | 600.00 | do | 40 |
| 60 | Mrs. A. C. Brown | do | A-8 | 1902 | Dug, 3½ by 3½ foot | 89 | 70 | 20 | 115 | Hand | 20.00 | 3.50 | Stock | |
| 61 | J. E. Paradis | do | A-8 | 1881? | Bored, 7-inch | 94 | 81 | 198 | | Gas | 300.00 | 1,000.00 | Irrigation | 75 |
| 62 | W. D. Suly | do | A-7 | 1892 | Bored, 6-inch? | 90 | 82 | 200 | | Wind | 150.00 | 30.00 | Domestic | 1½ |
| 63 | F. M. Elliott | San Antonio | A-7 | 1895? | Bored, 7-inch | 84 | 84 | 200 | 33 | Gas, artesian | | 900.00 | Domestic; irrigation. | 30 |
| 64 | Francis E. Barron | San Pedro | A-7 | 1898 | do | 79 | 79 | 260 | 40 | Artesian | 400.00 | | do | |
| 65 | H. P. Schildwachter | San Antonio | A-7 | 1883 | do | 82 | 82 | 140 | | Wind, artesian | | 145.00 | Domestic | |
| 66 | F. L. Walton | do | A-7 | 1895 | Hydraulic, 2-inch | 84 | 84 | 223 | 43 | do | 100.00 | 140.00 | do | Small. |
| 67 | do | do | A-6,7 | 1895 | do | 87 | 87 | 228 | | do | 180.00 | 150.00 | do | |
| 68 | J. E. Lodge | do | A-6 | 1897 | Bored, 7-inch | 88 | 88 | 200 | 44 | Gas, artesian | 350.00 | 600.00 | Irrigation; domestic. | 75 |
| 69 | E. S. Gunby | do | A-6 | 1888 | do | 91 | 91 | 240 | | do | 500.00 | 750.00 | do | 85 |
| 70 | I. E. Herson | do | A-6 | 1900 | do | 91 | 91 | 250 | | do | 350.00 | 700.00 | do | 60 |
| 71 | Geo. Wittman | do | A-5 | | do | 96 | 91 | | 43 | Artesian | | | Domestic | †5 |
| 72 | G. H. Bollinger | do | A-5,6 | 1883 | do | 98 | 98 | 240 | 42 | do | 600.00 | | do | †1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 73 | J. G. Bellou | do | A-5 | 1889 | do | 100 | 100 | 70 | 55 | do | 100.00 | | Domestic; irrigation. | |
| 74 | Miss Hersey | do | A-5 | 1891 | Bored, 10-inch | 102 | 102 | 80 | | do | | | Irrigation | 1 |
| 75 | Z. A. Towne | do | A-4,5 | 1897 | Bored, 7-inch | 112 | 112 | 77 | 56 | do | 77.00 | | Domestic; irrigation. | 15 |
| 76 | Mrs. L. Diller | do | A-5 | 1882 | do | 112 | 112 | 87 | 61 | do | | | Domestic | Small. |
| 77 | Mrs. F. E. Rausaur | do | A-4 | 1881 | Bored, 10-inch | 117 | 117 | 72 | 51 | Wind, artesian | 90.00 | 200.00 | do | |
| 78 | David Elcoat | do | A-4 | 1896 | Bored, 7-inch | 123 | 123 | 87 | 55 | do | 100.00 | 50.00 | do | |
| 79 | H. D. Merrill | do | A-4 | 1883 | do | 130 | 124 | 120 | 66 | Gas | 125.00 | 350.00 | Irrigation | 50 |
| 80 | A. E. Putney | do | A-3 | 1892 | do | 135 | 126 | 137 | 66 | Compressed air | 225.00 | 1,000.00 | do | 70 |
| 81 | J. N. Stone | do | A-3 | 1873 | do | 134 | 127 | 122 | 61 | Gas | 180.00 | 550.00 | Irrigation; domestic. | 50 |
| 82 | Hugh Glassell | do | A-3 | 1872 | Bored, 12-inch | 144 | 126 | | | do | | | Irrigation | 75 |
| 83 | A. D. Westbrook | do | A-3 | | Bored, 7-inch | 144 | 127 | 112 | 53 | Wind | | | Domestic | |
| 84 | Mrs. Jennie E. Fall | do | A-3 | 1902 | do | 151 | 127 | 67 | 71 | do | 85.00 | 50.00 | do | 1 |
| 85 | Michael Cudahy | do | B-3 | 1889 | do | 144 | 131 | 35 | 47 | do | | 125.00 | do | |
| 86 | do | do | B-3 | 1890 | do | 137 | 134 | 140 | | do | 90.00 | 75.00 | do | |
| 87 | E. Northcote | do | A-3 | | do | 133 | 124 | 120 | | do | | | do | |
| 88 | Mr. Slauson | do | B-3 | 1882? | do | 134 | 126 | 133 | 49 | Hand | | | do | |
| 89 | H. T. Starks | do | A-4 | 1900 | Bored, 10-inch | 122 | 121 | 132 | 37 | Gas | 400.00 | 800.00 | Irrigation | 100 |
| 90 | Jacob Bosshard | do | A-4 | 1898 | Bored, 7-inch | 126 | 122 | 85 | 63 | Wind | 102.00 | 200.00 | Domestic | 1 |
| 91 | Mrs. Mary Tweedy | do | B-4 | 1887 | Bored, 4-inch | 126 | 123 | 113 | 57 | do | | | do | 1 |
| 92 | F. H. Robinson | do | B-4 | 1885 | Bored, 7-inch | 109 | 108 | 106 | 52 | do | | 100.00 | do | 1 |
| 93 | Mrs. H. C. Carson | San Pedro | B-7 | 1875 | Bored, 2-inch | 75 | 75 | 259 | 32 | Artesian | | | do | |
| 94 | P. J. Boland | do | B-7 | 1890 | Bored, 4-inch | 76 | 76 | 135 | 37 | do | | | do | |
| 95 | L. F. Stockwell | San Antonio | B-6,7 | 1898 | Bored, 3-inch | 75 | 75 | 241 | | do | 100.00 | | Domestic; irrigation. | 10 |
| 96 | Mr. F. Walton | San Pedro | B-7 | | Bored, 7-inch | 74 | 74 | 250 | 31 | do | | | Irrigation; stock | |
| 97 | D. W. Imbler | do | A-7 | 1902 | do | 80 | 80 | 257 | 36 | do | 355.00 | | Irrigation | 50 |
| 98 | S. J. Hull | do | A-7 | 1900 | do | 78 | 78 | 247 | 33 | do | 500.00 | | do | 75 |
| 99 | J. Schaefer | do | B-7 | 1888 | do | 73 | 73 | 320 | 36 | do | 500.00 | | Irrigation; domestic. | |
| 100 | S. Stockwell | do | C-7 | 1885 | do | 81 | 81 | 144 | 41 | do | 700.00 | | do | 20 |
| 101 | G. F. Howe | do | D, E-8 | 1900 | do | 65 | 65 | 167 | 30 | Hand | | | Domestic | |
| 102 | J. B. Proctor | do | D-8 | | Bored, 4-inch | 70 | 70 | 145 | 29 | Hand, artesian | | | do | |
| 103 | C. Wright | do | D-8 | | Bored, 8-inch | 72 | 72 | | 29 | Artesian | | | do | |
| 104 | Los Angeles County | do | D-8 | 1900 | Hydraulic, 3-inch | 73 | 73 | 208 | 36 | do | 150.00 | | Roads | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 105 | E. M. James | San Pedro | C-8 | 1902 | Driven, 2½-inch | 71 | 71 | 117 | 35 | Wind | $75.00 | $125.00 | Domestic | |
| 106 | A. J. Morrison & Co | do | C-7 | 1893 | Bored, 8½-inch | 74 | 74 | 388 | 32 | Artesian | 1,000.00 | | Irrigation | †50 |
| 107 | do | do | C-8 | 1902 | Bored, 7-inch | 69 | 69 | 130 | 44 | Gas, artesian | 175.00 | 800.00 | do | †110 |
| 108 | L. A. Leavitt | do | C-8 | 1895 | Bored, 4-inch | 67 | 67 | 250 | 36 | Artesian | 250.00 | | Domestic | |
| 109 | R. H. Dinsmore | do | C-8 | 1901 | Bored, 3-inch | 69 | 69 | 268 | 36 | do | 225.00 | | do | 5 |
| 110 | T. F. Shields | do | C-8 | 1896 | Bored, 2-inch | 72 | 72 | 133 | 41 | Gas, artesian | 175.00 | 300.00 | Irrigation; domestic. | Small. |
| 111 | F. Colten | do | C-8 | 1880 | Bored, 7-inch | 72 | 72 | 140 | 41 | Wind, artesian | 250.00 | 150.00 | Domestic | |
| 112 | J. W. Duff | do | C-7 | 1897 | Hydraulic, 2-inch | 80 | 80 | 305 | 39 | Artesian | 200.00 | | do | |
| 113 | M. L. McIntosh | do | C-7 | 1877 | Bored, 7-inch | 78 | 78 | 330 | 38 | do | 500.00 | | do | 7 |
| 114 | Mrs. S. Kriem | do | C-7 | 1896 | do | 71 | 71 | 535 | 29 | do | 500.00 | | | 25 |
| 115 | R. B. Easley | do | C-7 | 1902 | Bored, 10-inch | 79 | 79 | 150 | 36 | Gas, artesian | 250.00 | 800.00 | Irrigation | †100 |
| 116 | H. Williams | do | C-7 | 1898 | Bored, 12-inch | 82 | 82 | 425 | 35 | Artesian | 800.00 | | do | †80 |
| 117 | G. Palmer | do | C-7 | 1896 | Bored, 7-inch | 76 | 76 | 135 | 40 | do | 150.00 | | Domestic; irrigation. | |
| 118 | F. Vennass | do | B-7 | 1875 | Bored, 5-inch | 75 | 75 | 145 | 40 | do | 150.00 | | Domestic; stock | |
| 119 | L. Abbott | do | B-7 | 1896 | Bored, 7-inch | 78 | 78 | 145 | 39 | do | 150.00 | | Irrigation; domestic. | |
| 120 | H. C. Carson | do | | 1873 | do | 73 | 73 | 264 | 31 | do | | | Domestic; irrigation. | |
| 121 | F. E. Stockwell | San Antonio | C-7 | 1893 | do | 83 | 83 | 148 | 33 | do | 150.00 | | Irrigation; domestic. | |
| 122 | E. H. Kincaid | do | C-7 | 1900 | Bored, 9-inch | 86 | 86 | 220 | 30 | do | 600.00 | | do | 8 |
| 123 | C. J. Williams & Co | do | C-6 | 1899 | Bored, 10-inch | 86 | 86 | 385 | 36 | do | 1,200.00 | | Irrigation | 30 |
| 124 | J. Gapper | do | C-6 | 1895 | Bored, 7-inch | 86 | 86 | 146 | 31 | Wind, artesian | 150.00 | 145.00 | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 125 | J. O. Waite | do | D-7 | 1900 | Bored, 9½-inch | 83 | 83 | 475 | 30 | Artesian | 900.00 | | Irrigation | 75 |
| 126 | S. S. Mills | do | D-7 | 1897 | Bored, 7-inch | 84 | 84 | 170 | 36 | Wind, artesian | | 70.00 | Domestic | |
| 127 | P. E. Hoag | do | D-7 | 1885 | do | 88 | 88 | 150 | 32 | Wind | | | do | |
| 128 | W. W. Young | do | D-6 | 1902 | Bored, 10-inch | 86 | 86 | 176 | 38 | Gas, artesian | 319.65 | 1,000.00 | Irrigation; domestic. | |
| 129 | W. C. Lee | San Pedro | D-7 | 1888 | Bored, 7-inch | 77 | 77 | 150 | 37 | Artesian | 200.00 | | Domestic | 15 |
| 130 | do | do | D-7 | 1900 | Bored, 10-inch | 78 | 78 | 390 | 30 | do | 800.00 | | Irrigation | 75 |
| 131 | C. Venza | do | D-7 | 1896 | Bored, 7-inch | 79 | 79 | 136 | 35 | Wind, hand | | | Domestic | |
| 132 | W. E. Boster | do | D-7 | 1880 | do | 81 | 81 | 283 | 36 | Hand | 550.00 | 10.00 | do | |
| 133 | Mrs. McCarty | San Antonio | D-7 | 1895 | Bored, 3-inch | 60 | 60 | 180 | 37 | Hand, artesian | | | do | |
| 134 | T. H. Abbott | do | D-6 | 1889 | Bored, 7-inch | 89 | 89 | 165 | 34 | Wind, artesian | 250.00 | 160.00 | do | Small. |
| 135 | B. T. Rozelle | do | E-6 | 1880 | do | 89 | 89 | 130 | 35 | do | 300.00 | 100.00 | do | Small. |
| 136 | do | do | D-6 | 1896 | Bored, 10-inch | 89 | 89 | 762 | 19 | Gas, artesian | 2,500.00 | 1,400.00 | Irrigation | 75 |
| 137 | C. H. Watts | do | D-6 | 1899 | do | 91 | 91 | 800 | 22 | Artesian | 2,800.00 | | do | †85 |
| 138 | W. B. Finch | do | C-6 | 1895 | Bored, 7-inch | 89 | 89 | 360 | 35 | do | | | Irrigation; domestic. | 75 |
| 139 | Elmer E. Moore | do | C-6 | 1895 | Bored, 10-inch | 95 | 95 | 467 | 25 | do | 1,150.00 | | Irrigation | †75 |
| 140 | do | do | C-6 | | Bored, 7-inch | 98 | 98 | 150 | 26 | Gas, artesian | 700.00 | 500.00 | do | 75 |
| 141 | do | do | C-6 | | do | 93 | 93 | 150 | 36 | Wind, artesian | 150.00 | 143.00 | Domestic | Small. |
| 142 | A. W. Andrews | do | C-6 | 1895 | do | 92 | 92 | 180 | 35 | do | | 35.00 | Domestic; irrigation. | |
| 143 | Mr. Carres | do | D-6 | 1903 | Bored, 12-inch | 91 | 91 | 652 | 33 | Artesian | 1,500.00 | | Irrigation | 100 |
| 144 | E. W. Lewis | do | C-6 | 1899 | do | 92 | 92 | 385 | 36 | do | 1,000.00 | | do | 200 |
| 145 | C. H. Sessions | do | B-7 | | Bored, 7-inch | 82 | 82 | 140? | 37 | Hand, artesian | | 10.00 | Domestic | 2 |
| 146 | do | do | C-5 | 1898 | Bored, 12-inch | 97 | 97 | 375 | 37 | Artesian | 600.00 | | Stock; irrigation | †100 |
| 147 | L. Snodgrass | do | B-5 | 1883? | Bored, 7-inch | 96 | 96 | 80 | 46 | do | 150.00 | | Domestic | 15 |
| 148 | do | do | B-5 | 1883? | do | 106 | 106 | 80 | 44 | do | 150.00 | | Stock; irrigation | |
| 149 | Omri Bullis | do | B-5 | 1901 | do | 92 | 92 | 80? | 39 | do | 100.00 | | Irrigation | 20 |
| 150 | do | do | B-6 | 1890? | do | 92 | 92 | 335 | 31 | Hand, artesian | 1,000.00 | | Irrigation; domestic. | |
| 151 | F. Hoppe | do | B-5 | 1903 | Bored, 10-inch | 99 | 99 | 385 | 37 | Artesian | 1,000.00 | | Irrigation | 30 |
| 152 | J. Tweedy | do | B-5 | 1893 | Bored, 4-inch | 111 | 111 | 72 | 48 | Hand, artesian | 75.00 | 10.00 | Domestic | |
| 153 | Mr. Gilky | do | C-5 | 1880 | Bored, 8-inch | 101 | 101 | 135 | 37 | Artesian | 300.00 | | Domestic; irrigation. | 30 |
| 154 | J. Abola | do | B-5 | | Bored, 7-inch | 102 | 102 | 135? | 45 | do | | | Stock; irrigation | 15 |
| 155 | B. R. Kratzer | do | C-5 | 1890? | do | 102 | 102 | 160 | 36 | Wind, artesian | 300.00 | 50.00 | Domestic | |
| 156 | K. Swantek | do | C-5 | 1903 | Bored, 10-inch | 104 | 104 | 156 | 35 | | 250.00 | | Not used | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 211 | J. L. Shepard | San Pedro | C-9 | 1901 | Bored, 7-inch | 55 | 50 | 100 | 36 | Wind | $45.00 | $150.00 | Domestic | |
| 212 | J. M. Spencer | do | C-9 | 1900 | Bored, 9½-inch | 52 | 52 | 570 | 32 | Artesian | 1,500.00 | | Irrigation | |
| 213 | J. J. Harshman | do | B-8 | 1900 | Bored, 12-inch | 65 | 65 | 480 | | do | 850.00 | | | Small. |
| 214 | John Hight | do | C-9 | 1902 | Bored, 10-inch | 54 | 50 | 135 | | Gas | 170.00 | | Irrigation | 80 |
| 215 | J. M. Shepard | do | C-9 | 1900 | do | 60 | 55 | 140 | | do | *1,000.00 | | do | 115 |
| 216 | Chas. A. Heath | do | C-9 | 1895 | Bored, 2-inch | 55 | 53 | 94 | | Hand | 50.00 | | Stock | |
| 217 | H. A. Wittich | do | C-9 | 1883? | Bored, 7-inch | 50 | 50 | 545 | 30 | Artesian | 2,000.00 | 120.00 | Domestic | |
| 218 | J. M. Hart | do | B-9 | 1902 | Bored, 12-inch | 57 | 57 | 655 | 34 | do | 2,000.00 | | Irrigation | 54 |
| 219 | J. J. Harshman | do | B-8 | 1897 | Bored, 2-inch | 65 | 65 | 350 | 34 | do | | | Domestic; irrigation. | |
| 220 | John Gries | do | B-8 | 1897 | do | 70 | 70 | 252 | 34 | do | 152.00 | | Stock | |
| 221 | W. J. Higgins | do | A-8 | 1868 | Bored, 7-inch | 78 | 68 | 114 | 33 | Wind | | | Domestic; irrigation. | |
| 222 | A. M. Peck | do | C-8 | 1878? | do | 62 | 57 | 130 | 42 | do | 200.00 | | Domestic; stock | |
| 223 | H. B. Rice | do | C-8 | 1873 | do | 62 | 57 | 130 | 38 | do | 200.00 | 100.00 | Domestic | |
| 224 | John Hight | do | D-8 | 1898 | Bored, 3-inch | 61 | 56 | 70 | 41 | Hand | 35.00 | | do | |
| 225 | W. P. Anderson | do | C-8 | 1883? | Bored, 7-inch | 64 | 64 | 380 | 38 | Artesian | 2,000.00 | | Domestic; stock | |
| 226 | F. K. Day | do | D-8 | 1901 | Bored, 2-inch | 64 | 64 | 105 | 36 | Hand | 45.00 | | Domestic | |
| 227 | D. R. Meyers | do | D-8 | 1888? | Bored, 4-inch | 66 | 60 | 130 | 35 | Wind | | | do | |
| 228 | R. B. Harris | do | D-8 | 1873? | Bored, 7-inch | 63 | 58 | 100 | 35 | do | | 100.00 | do | |
| 229 | do | Los Cerritos | E-9 | 1891 | Bored, 3-inch | 63 | 58 | 100 | 35 | Hand | 50.00 | | do | |
| 230 | E. R. Collingridge | San Pedro | D-8 | 1885 | Bored, 7-inch | 67 | 66 | 132 | | Not raised | 250.00 | | Not used | |
| 231 | do | do | D-8 | 1894 | do | 66 | 66 | 566 | 32 | Artesian | 1,500.00 | | Irrigation | 42 |
| 232 | A. Anderson | do | D-8 | 1898 | Bored, 2-inch | 65 | 65 | | 35 | Wind | | | Stock | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 233 | W. H. Craig | do | D-8 | | Bored, 7-inch | 67 | 62 | 125 | 36 | Hand | | | Domestic | |
| 234 | F. Voigt | do | D-9 | | Bored, 2-inch | 57 | 52 | 170? | 31 | do | | | do | |
| 235 | Chester Robertson | do | D-9 | 1883? | do | 55 | 55 | 200 | 37 | Wind | | | do | |
| 236 | Mr. Kelsey | do | D-9 | | do | 57 | 52 | | 39 | Hand | | | do | |
| 237 | Mrs. S. Buckham | do | D-9 | 1892? | Bored, 4-inch | 55 | 50 | 100? | 37 | do | | | do | |
| 238 | J. H. Orr | do | D-9 | | Hydraulic, 2-inch | 55 | 55 | 550 | 31 | Artesian | | | do | |
| 239 | do | do | D-9 | 1892 | Hydraulic, 4-inch | 55 | 55 | 400 | 32 | Hand | | | do | |
| 240 | do | do | D-9 | 1893? | Bored, 7-inch | 51 | 51 | 360 | 32 | Artesian | | | Irrigation | |
| 241 | do | do | D-9 | 1899 | Hydraulic, 3-inch | 51 | 51 | 360 | 28 | do | 500.00 | | do | |
| 242 | J. M. Shepard | do | C-9 | | Driven, 2-inch | 56 | 51 | 110 | 51 | Wind | | | Domestic | |
| 243 | Nelson Ward | do | C-9 | 1875? | Bored, 7-inch | 53 | 47 | 175 | 35 | do | 600.00 | 135.00 | Domestic; stock | |
| 244 | James Taylor | do | C-9 | 1902 | Bored, 5-inch | 54 | 46 | 130 | 38 | do | 100.00 | 65.00 | Domestic | |
| 245 | Chas. A. Heath | do | C-9 | 1903 | Hydraulic, 2-inch | 54 | 53 | 104 | 38 | Hand | 50.00 | | do | |
| 246 | J. J. Harshman | do | B-8 | 1885 | Bored, 3-inch | 65 | 61 | 90 | 40 | Not raised | | | Not used | |
| 247 | John Gries | do | B-8 | | | 74 | 66 | 100 | 67 | Wind | | | Domestic | |
| 248 | Mrs. E. Loughrey | do | A-8 | 1891? | Dug, 4 by 4 foot | 88 | 64 | 26 | 77 | Hand | | | Stock | |
| 249 | Geo. Clark | do | A-8 | 1901 | Bored, 9½-inch | 88 | 68 | 369 | 29 | Wind | 686.00 | 150.00 | Domestic; irrigation. | |
| 250 | Sisters of Charity | do | A-8 | | Bored, 7-inch | 88 | 64 | 134 | 39 | Hand | | | Not used | |
| 251 | Wm. Duff | do | A-8 | 1883 | Dug, 3 by 3 foot | 92 | 65 | 30 | 53 | Wind | | | Domestic | |
| 252 | do | do | A-8 | 1902 | Bored, 12-inch | 90 | 67 | 340+ | | Artesian | | | | |
| 253 | Compton Rural Cemetery. | do | A-9 | 1873 | Driven, 4-inch | 75 | 65 | 70 | 36 | Wind | | | Irrigation | |
| 254 | J. K. Morrison | do | A-9 | 1880 | Dug, 3-foot diameter. | 95 | 66 | 35 | 44 | do | | | Domestic | |
| 255 | I. W. Hellman | do | A-9 | | Bored, 7-inch | 99 | 65 | 174 | 31 | do | | | Stock | |
| 256 | J. Francis | do | A-11 | | Dug, 3 by 3 foot | 75 | 23 | 55 | 105 | do | | | do | |
| 257 | G. Delamo | do | A-11 | 1897 | Bored, 7-inch | 50 | 32 | 200+ | 36 | do | | | Domestic; stock | |
| 258 | Mrs. Carson | do | B-10 | 1878? | Bored, 6-inch | 75 | | 250 | 40 | Wind, gas | | | Domestic; irrigation. | |
| 259 | do | do | B-10 | 1882? | Dug, 3-foot diameter. | 75 | 55 | 30 | 62 | Wind | | 150.00 | Irrigation | |
| 260 | W. A. Hall | do | B-8 | 1872? | Bored, 7-inch | 62 | | 165 | 35 | Hand | 200.00 | | Domestic | |
| 261 | David Gates | do | B-8 | 1873? | do | 66 | 66 | 110 | 33 | Artesian | 250.00 | | do | Small. |
| 262 | do | do | B-8 | 1899 | do | 68 | 68 | 450 | | do | 285.00 | | Not used | |
| 263 | do | do | B-9 | 1873? | do | 68 | 68 | 150 | 33 | do | 250.00 | | Stock | |
| 264 | Los Angeles Bank | do | B-8 | 1897? | do | 65 | 65 | 120 | 34 | Gas | | | Irrigation | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 265 | Los Angeles Bank | San Pedro | B-8,9 | 1878? | Bored, 7-inch | 65 | 65 | 300 | 35 | Artesian | | | Irrigation | |
| 266 | Mrs. M. Wilson | do | B-9 | 1873? | Dug, 8-foot diameter. | 75 | 65 | 13 | 42 | Wind | | $75.00 | Domestic; stock | |
| 267 | J. M. Hart | do | B-8 | | Driven, 3-inch | 57 | 57 | 518 | 29 | Artesian | | | Domestic; irrigation. | Small. |
| 268 | do | do | B-9 | | Bored, 3-inch | 57 | 57 | 316 | 31 | do | | | Stock | |
| 269 | Pac. Electric R. R. Co. | do | B-10 | | Dug, 6 by 8 foot | 52 | 50 | 15? | | Electric motor | | | Domestic | |
| 271 | Mrs. Geo. Carson | do | C-10 | 1898 | Driven, 2-inch | 51 | 51 | 350 | 33 | Artesian | | | do | Small. |
| 272 | J Francis | do | C-10 | 1894 | Bored, 2-inch | 50 | | 85 | 37 | Wind | $35.00 | 100.00 | Domestic; stock | |
| 273 | do | do | C-10 | 1903 | Bored, 10-inch | 50 | | 125 | | Not installed | | | Irrigation | |
| 274 | Miss Dominguez | do | B-10 | | Driven, 2-inch | 50 | | 90 | 37 | Hand | 35.00 | | Domestic | |
| 275 | J. M. Spencer | do | C-9 | 1876? | Bored, 7-inch | 52 | 52 | 250 | 32 | Artesian, and wind. | 1,400.00 | 50.00 | Domestic; stock. | Small. |
| 277 | T. W. Edwards | do | C-8 | 1896 | Driven, 2-inch | 69 | 69 | 700 | 31 | Artesian | | | Irrigation | |
| 278 | do | do | C-8 | 1897 | do | 69 | 69 | 700 | 31 | do | | | Irrigation; stock | |
| 279 | J. S. Martin | do | C-8 | 1902 | Bored, 7-inch | 69 | 66 | 132 | 39 | Gas | 100.00 | 1,200.00 | Irrigation | †100 |
| 280 | do | do | C-8 | 1899 | Bored, 2-inch | 69 | 69 | 376 | 32 | Artesian | 122.50 | | Domestic; irrigation. | †9 |
| 281 | H. W. Marden | Los Cerritos | E-8 | 1901 | do | 65 | 65 | 100 | 33 | do | | | Not used | |
| 282 | J. G. Bilen | do | D-8 | | do | 61 | 61 | 320? | 33 | do | | | Stock | †4 |
| 283 | L. A. Clark | do | D-8 | 1901 | Bored, 2½-inch | 61 | 61 | 128 | | do | 64.00 | | Irrigation | Small. |
| 284 | do | do | D-9 | 1898 | Bored, 2-inch | 61 | 61 | 310 | 32 | do | 160.00 | | do | 3 |
| 285 | H. P. Epperson | do | E-8 | 1902 | do | 60 | 60 | 159 | 29 | do | 64.00 | | Stock | |
| 286 | James Kerr | do | D-9 | 1902 | do | 57 | 57 | 400 | 34 | do | 180.00 | | Domestic | Small. |
| 287 | J. Clarbour | do | E-8,9 | 1891 | Driven, 2-inch | 60 | 60 | 285 | 32 | do | | | Irrigation | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 288 | .....do..... | .....do..... | E-8,9.... | 1891 | Driven, 3-inch.... | 60 | 60 | 490 | .... | .....do..... | ..... | ..... | .....do..... | ..... | |
| 289 | .....do..... | .....do..... | E-9..... | 1891 | Bored, 2-inch..... | 59 | 59 | 485 | 31 | .....do..... | ..... | ..... | Domestic..... | ..... | |
| 290 | .....do..... | .....do..... | E-9..... | 1891 | Bored, 3-inch..... | 59 | 59 | 485 | .... | .....do..... | ..... | ..... | Stock..... | ..... | |
| 291 | F. M. Noroom..... | .....do..... | D-9..... | 1900 | Bored, 4-inch..... | 53 | 53 | 485 | 35 | .....do..... | 300.00 | ..... | Domestic; irrigation. | 34 | |
| 292 | .....do..... | .....do..... | D-9..... | 1901 | .....do..... | 54 | 54 | 87 | 31 | .....do..... | 80.00 | ..... | Irrigation..... | 25 | |
| 293 | .....do..... | .....do..... | D-9..... | 1901 | .....do..... | 54 | 54 | 87 | 31 | .....do..... | 80.00 | ..... | .....do..... | 25 | |
| 294 | J. C. Timmons..... | .....do..... | D-9..... | 1901 | Bored, 2-inch..... | 53 | 53 | 465 | 32 | .....do..... | 235.00 | ..... | Domestic; irrigation. | 7 | |
| 295 | .....do..... | .....do..... | D-9..... | 1901 | .....do..... | 51 | 51 | 367 | 32 | .....do..... | 200.00 | ..... | Irrigation..... | 7 | |
| 296 | J. Stimson..... | .....do..... | D-9..... | 1896 | Bored, 3-inch..... | 52 | 52 | 75 | .... | .....do..... | 75.00 | ..... | .....do..... | Small. | |
| 297 | .....do..... | .....do..... | D-9..... | 1897 | Bored, 2-inch..... | ..... | ..... | 420 | 31 | .....do..... | 200.00 | ..... | Domestic; irrigation. | 6 | |
| 298 | S. O. Houghton..... | .....do..... | D-10.... | 1900 | Bored, 2½-inch.... | 50 | 50 | 320 | 31 | Artesian, wind.. | ..... | ..... | Domestic; stock. | ..... | |
| 299 | G. Klippel..... | .....do..... | D-9..... | 1900 | Bored, 2-inch..... | 51 | 51 | 355 | 32 | Artesian..... | 125.00 | ..... | Irrigation..... | 6 | |
| 300 | .....do..... | .....do..... | D-10.... | 1899 | .....do..... | 51 | 51 | 280? | 33 | .....do..... | 105.00 | ..... | .....do..... | 4 | |
| 301 | .....do..... | .....do..... | E-10.... | 1897 | .....do..... | 52 | 52 | 350 | 33 | .....do..... | 125.00 | ..... | Stock..... | 4 | |
| 302 | .....do..... | .....do..... | D, E-9.. | 1897 | .....do..... | 52 | 52 | 86 | 26 | .....do..... | 75.00 | ..... | Domestic; stock. | ..... | |
| 303 | G. H. Bixby..... | .....do..... | D-10.... | 1903 | Bored, 12-inch.... | 50 | 50 | 907 | 26 | .....do..... | ..... | ..... | Irrigation..... | 30 | |
| 304 | .....do..... | .....do..... | D-10.... | 1880 | Bored, 4-inch..... | 49 | 49 | 400? | 37 | .....do..... | ..... | ..... | Domestic..... | ..... | |
| 305 | .....do..... | .....do..... | D-10.... | 1898 | Bored, 2-inch..... | 49 | 49 | 400? | 28 | .....do..... | ..... | ..... | .....do..... | ..... | |
| 306 | .....do..... | .....do..... | C-10.... | 1898 | .....do..... | 49 | 49 | 420 | 32 | .....do..... | ..... | ..... | Domestic; irrigation. | Small. | |
| 307 | .....do..... | .....do..... | C-10.... | 1898 | .....do..... | 49 | 49 | 440 | 32 | .....do..... | ..... | ..... | Domestic; stock. | Small. | |
| 308 | .....do..... | .....do..... | D-11.... | 1890? | Bored, 7-inch..... | 50 | 50 | 300? | 31 | .....do..... | ..... | ..... | ..... | 1 | |
| 309 | .....do..... | .....do..... | D-11.... | ..... | .....do..... | 49 | 49 | 350? | .... | .....do..... | ..... | ..... | Not used..... | ..... | |
| 310 | .....do..... | .....do..... | D-10.... | 1903 | Bored, 12-inch.... | 51 | 51 | 682 | 26 | .....do..... | ..... | ..... | Irrigation..... | 29 | |
| 311 | .....do..... | .....do..... | D-10.... | 1890? | Bored, 2-inch..... | 52 | 52 | 350 | .... | .....do..... | ..... | ..... | Stock..... | Small. | |
| 312 | J. Worst..... | .....do..... | E-10.... | 1900 | .....do..... | 54 | 54 | 400 | 30 | .....do..... | 140.00 | ..... | Irrigation; stock | ..... | |
| 313 | .....do..... | .....do..... | E-10.... | ..... | Bored, 3-inch..... | 54 | 54 | 160 | 32 | Hand, artesian.. | ..... | ..... | Irrigation..... | ..... | |
| 314 | F. E. Green..... | .....do..... | E-10.... | 1899 | Bored, 2-inch..... | 56 | 56 | 398 | 33 | Artesian..... | 160.00 | ..... | .....do..... | ..... | |
| 315 | .....do..... | .....do..... | E-10.... | 1889 | Bored, 7-inch..... | 55 | 55 | 85 | 26 | Wind..... | ..... | ..... | Domestic; irrigation | ..... | |
| 316 | G. W. Calionette..... | .....do..... | E-9..... | 1899 | Bored, 2-inch..... | 61 | 61 | 368 | 31 | Artesian..... | 300.00 | ..... | Irrigation..... | ..... | |
| 317 | Ed White ..... | .....do..... | E-9..... | 1888 | Bored, 6-inch..... | 60 | 60 | 150 | 30 | .....do..... | 150.00 | ..... | Domestic..... | ..... | |
| 318 | Z. Lent..... | .....do..... | E-9..... | ..... | Bored, 2-inch..... | 55 | 55 | 330 | 32 | .....do..... | ..... | ..... | Irrigation; domestic. | Small. | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 319 | A. E. Matson | Los Cerritos | E-9 | 1890 | Bored, 3-inch | 61 | 61 | 400 | 28 | Artesian | $200.00 | | | |
| 320 | do | do | E-9 | 1889 | Bored, 2-inch | 61 | 61 | 380 | | do | 125.00 | | Irrigation | |
| 321 | Mr. Hamilton | do | E-9 | | do | 60 | 60 | 90 | | do | | | Domestic; stock | |
| 322 | do | do | E-9 | | Bored, 4-inch | 60 | 60 | 103 | 29 | do | | | Stock | 4 |
| 323 | do | do | E-9 | | Bored, 6-inch | 60 | 60 | 200 | 28 | do | | | Irrigation | Small. |
| 324 | Z. Lent | do | E-9 | 1897 | Bored, 2-inch | 55 | 55 | 350? | 32 | do | | | Stock; irrigation | |
| 325 | do | do | E-9 | 1897 | do | 55 | 55 | 100+ | 33 | do | | | Irrigation; stock | |
| 326 | R. H. Parker | do | E-9 | 1899 | do | 57 | 57 | 567 | 32 | do | 200.00 | | Irrigation | 4 |
| 327 | Lydia Withers | do | E-9 | 1899 | Bored, 4-inch | 61 | 56 | 30 | 34 | Wind | | | Stock | |
| 328 | H. A. Davis | do | E-9 | 1895 | Bored, 2-inch | 63 | 63 | 151 | | Artesian | 45.45 | | Irrigation | |
| 329 | H. P. Epperson | do | E-9 | 1897 | do | 63 | 63 | 631 | 26 | do | 300.00 | | do | |
| 330 | John MacIlmoil | do | E-8 | 1898 | do | 66 | 66 | 610 | 25 | do | 250.00 | | do | 1 |
| 331 | do | do | E-8 | 1898 | do | 66 | 66 | 210 | 25 | do | 100.00 | $200.00 | Irrigation; domestic. | 1 |
| 332 | M. C. Isom | do | E-8 | 1895 | do | 70 | 70 | 158 | 25 | Wind, artesian | 100.00 | 100.00 | Domestic | |
| 333 | E. Mason | do | E-8 | 1890 | Bored, 5-inch | 69 | 69 | 140 | 28 | Hand | 150.00 | | Stock; domestic | |
| 334 | do | do | E-8 | 1890 | Bored, 4-inch | 69 | 69 | 165 | 28 | do | 150.00 | | Domestic; stock | |
| 335 | F. O. Sward | do | E-8 | 1899 | Bored, 2-inch | 70 | 70 | 180 | 31 | Wind | | | Domestic | |
| 336 | do | do | E-8 | 1903 | do | 69 | 69 | 169 | | Artesian | 75.00? | | Irrigation | |
| 337 | M. J. Luccock | do | E-8 | 1890 | Bored, 4-inch | 73 | 73 | 280 | 26 | Hand | 200.00+ | | Domestic | |
| 338 | Chas. Roberts | do | E-8 | 1892 | Bored, 2-inch | 72 | 71 | 114 | 26 | Wind | 15.00 | 30.00 | do | |
| 339 | do | do | E-8 | 1901 | Bored, 3-inch | 72 | 72 | 140 | | Wind, gas | 93.00 | 200.00 | Irrigation | |
| 340 | Clearwater Cooperative Creamery. | do | E-8 | 1902 | Bored, 2-inch | 76 | 76? | 160 | 27 | Gas, artesian | 50.00 | | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 341 | E. A. Rodgers | do | E-8 | 1883? | do | 75 | 75 | 125 | 26 | Artesian | 50.00 | | Stock | |
| 342 | S. N. Jennings | do | E-7 | 1889 | Bored, 7-inch | 74 | | 130 | 26 | Wind | | | Domestic | |
| 343 | do | do | E-7 | 1900 | Bored, 10-inch | 77 | 77 | 155 | 25 | Hand, artesian | 200.00 | | Irrigation; stock | |
| 344 | do | do | E-8 | 1891 | Bored, 7-inch | 70 | 70 | 351 | 26 | Artesian | 200.00? | | Stock | |
| 345 | J. V. Stewart | do | E-7 | 1897 | Bored, 2-inch | 77 | 77 | 150 | 25 | do | 70.00 | | Stock; domestic | |
| 346 | do | do | E-7 | 1897 | Bored, 3-inch | 79 | 79 | 150 | 25 | do | 70.00 | | Stock; irrigation | 10 |
| 347 | C. Harduc | do | E-7 | 1898 | Bored, 10-inch | 75 | 75 | 163 | | Gas, artesian | | | Irrigation | 3 |
| 348 | do | do | E-7 | 1895 | Bored, 7-inch | 77 | 77 | 150 | 25 | Artesian | | | Not used | †60 |
| 349 | L. Stiner | do | E-7 | 1901 | do | 75 | 75 | 150 | 26 | Hand, artesian. | 180.00 | | Domestic; irrigation. | |
| 350 | do | do | E-7 | 1899 | Bored, 2-inch | 75 | 75 | 150 | 25 | Artesian | 60.00 | | Stock | |
| 351 | Henry Carson | do | E-7 | 1897? | Bored, 4-inch | 75 | 75 | 140 | 26 | do | 80.00 | | Domestic | Small. |
| 352 | do | do | E-7 | 1897? | Bored, 6-inch | 75 | 75 | 140 | 27 | do | 125.00 | | Not used | |
| 353 | R. A. McCurdy | do | E-7 | 1897 | Bored, 7-inch | 80 | 80 | 150 | 27 | do | | | Domestic; stock. | Small. |
| 354 | Geo. Hinman | do | E-7 | 1891 | Bored, 4-inch | 80 | 80 | 156 | 26 | do | 125.00 | | Domestic | 14 |
| 355 | H. J. Kent | do | E-7 | 1898? | Bored, 7-inch | 79 | 79 | 150 | 27 | do | 150.00? | | do | |
| 356 | J. M. Williams | do | E-7 | 1902 | Bored, 2-inch | 81 | 81 | 128 | 26 | do | 53.00 | | do | |
| 357 | Geo. A. Williams | do | E-6,7 | 1899 | do | 81 | 81 | 117 | 26 | do | | | do | |
| 358 | P. Gunn | do | E-7 | | do | 81 | 81 | 130 | 26 | do | | | do | |
| 359 | Orr & Orr | San Antonio | D-8 | 1894 | Bored, 7-inch | 71 | 71 | 180 | | do | | | do | |
| 360 | do | do | D-8 | 1894 | Bored, 9½-inch | 71 | 71 | 390 | 33 | do | | | Irrigation | 26 |
| 361 | Carpenter estate | San Pedro | D-7 | 1897? | Bored, 10-inch | 77 | 77 | 230 | 35 | Gas, artesian | | | do | †155 |
| 362 | do | do | D-7 | 1897? | do | 74 | 74 | 230 | 26 | do | | | do | |
| 363 | do | do | E-7 | | Bored, 8-inch | 76 | 77 | 161 | | | | | Not used | |
| 364 | do | do | D-8 | | Bored, 10-inch | 73 | 73 | | 32 | Hand | | | Domestic; stock. | |
| 365 | Chas. F. Williams | do | D-8 | 1890 | Bored, 7-inch | 65 | 62 | 147 | 33 | do | | | Domestic | |
| 366 | J. H. Williams | do | D-8 | 1888 | do | 72 | 71 | 186 | | Artesian | 400.00 | | do | |
| 367 | Compton City school district. | do | D-8 | 1891 | Hydraulic, 3-inch. | 72 | | 150 | 33 | Hand | | | do | |
| 368 | John Morton | do | D-8 | 1902 | Bored, 7-inch | 74 | 73 | 133 | | Gas | 150.00 | | Irrigation | 125 |
| 369 | H. H. Taylor | do | C-8 | 1890 | Bored, 2-inch | 71 | 71 | 250 | 34 | Artesian | 350.00 | | Domestic | 1 |
| 370 | J. J. Morton | do | C-7 | 1876 | Bored, 7-inch | 75 | 70 | 360 | | Gas | 2,000.00 | | Irrigation | †100 |
| 371 | do | do | C-7 | 1896 | Hydraulic, 2-inch. | 72 | 72 | 133 | 32 | Artesian | 200.00 | | Domestic | |
| 372 | do | do | C-8 | 1883 | Hydraulic, 3-inch. | 72 | 69 | 130 | 33 | Gas | 200.00 | | Irrigation; domestic. | 125 |
| 373 | Mrs. A. Mayo | do | C-8 | 1875 | Bored, 6-inch | 72 | 68 | 150 | 33 | do | | | Domestic | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 374 | Mrs. A. Mayo | San Pedro | C-7 | 1883 | Bored, 7-inch | 75 | 70 | 150 | 35 | Gas | $200.00 | | Irrigation | †75 |
| 375 | J. A. Howie | do | C-7 | | do | 72 | 69 | 125 | 35 | Wind | 200.00 | $100.00 | Stock; domestic | |
| 376 | G. W. Neece | do | C-8 | 1891 | do | 75 | 75 | 150 | | Gas | 250.00 | 800.00 | Irrigation | 125 |
| 377 | do | do | C-7 | 1890 | do | 72 | 68 | 150 | | Wind | 250.00 | 150.00 | Domestic | |
| 378 | Mr. Marlowe | do | D-7 | 1877 | do | 80 | 77 | 150 | 34 | Hand | | | do | |
| 379 | Sherman estate | do | D-7 | 1892 | Bored, 5-inch | 80 | 76 | 150 | 34 | do | | | do | |
| 380 | M. A. Rozelle | do | D-7 | | Bored, 2-inch | 81 | | 117 | 37 | do | 35.00 | | do | |
| 381 | Chas. Tibbetts | San Antonio | D-7 | 1902 | Bored, 10-inch | 82 | 81 | 162 | 34 | Gas | 275.00 | 800.00 | Irrigation | 75 |
| 382 | do | do | D-7 | 1883? | Bored, 5-inch | 82 | 77 | 150? | 34 | Hand | | | Domestic | |
| 383 | Geo. W. Phelan | do | E-6,7 | 1897? | Bored, 9-inch | 82 | 82 | 680 | 25 | Gas | | | Irrigation | †150 |
| 384 | do | do | E-7 | 1897? | Bored, 7-inch | 82 | 81 | 300+ | 25 | do | | | do | |
| 385 | do | do | E-7 | 1897 | Bored, 2-inch | 82 | | 160 | | Artesian | | | Not used | |
| 386 | do | do | E-7,8 | 1897 | Bored, 8-inch | 82 | 81 | 300 | | | | | do | |
| 387 | do | do | E-7 | | Bored, 7-inch | 80 | | 250 | 26 | Hand | | | Domestic | |
| 388 | do | do | D-7 | | Bored, 2-inch | 80 | | 160 | | Artesian | | | Stock | |
| 389 | E. E. Beazley | do | D-7 | | do | 80 | 80 | 160 | | do | | | Not used | |
| 390 | F. C. Carroll | do | D-7 | 1883 | Bored, 7-inch | 84 | 81 | 180 | 33 | Gas | | 600.00 | Irrigation | 75 |
| 391 | V. H. Stillwell | do | D-6 | 1902 | Bored, 10-inch | 88 | 88 | 176 | 35 | do | 260.00 | 800.00 | do | 100 |
| 392 | T. H. Abbott | do | D-6 | 1900 | do | 90 | 88 | 169 | 33 | do | 300.00 | 825.00 | do | |
| 393 | B. T. Rozelle | do | D-6 | 1895 | Bored, 12-inch | 87 | 86 | 169 | | do | 350.00 | | do | 200 |
| 394 | C. H. Watts | do | E-6 | 1891 | Bored, 4-inch | 87 | 83 | 140 | 25 | Wind | 150.00 | | Domestic | |
| 395 | do | do | D-6 | 1893 | Bored, 7-inch | 87 | 87 | 300 | | | | | Not used | |
| 396 | Dr. Davis | do | E-5 | 1891 | Bored, 4-inch | 96 | 88 | 150 | 30 | Hand | 40.00 | | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 397 | Alexander Gunn | do | E-5 | 1903 | Bored, 12-inch | 100 | 100 | 625 | 23 | Artesian | 1,600.00 | | Irrigation | | 54 |
| 398 | do | do | E 5 | 1889 | Bored, 4-inch | 100 | 100 | 556 | | do | | | Not used | | |
| 399 | do | do | D-5 | 1890 | Bored, 6-inch | 85? | 85 | 550? | 31 | do | | | Stock | | |
| 400 | R. Gilhousen | do | E-5 | 1902 | Bored, 10-inch | 98 | 91 | 154 | 27 | Gas | 350.00 | 950.00 | Irrigation | | 85 |
| 401 | do | do | E-5 | 1898 | Bored, 2-inch | 98 | 91 | 128 | 27 | Wind | | 175.00 | Domestic | | |
| 402 | D. Lane | do | E-6 | 1899 | Bored, 12-inch | 90 | 90 | 757 | 25 | Artesian | 2,000.00 | | Irrigation | | 61 |
| 403 | J. B. Norton | do | D-5 | 1880? | Bored, 7-inch | 100 | | 200? | 41 | Wind | | | Domestic | | |
| 404 | L. Snodgrass | do | C-5 | 1897 | Bored, 12-inch | 103 | 103 | 800 | 34 | Artesian | 4,000.00 | | Irrigation | | 35 |
| 405 | do | do | D-5 | 1895 | Bored, 10-inch | 103 | 99 | 150 | 36 | Gas | | 1,400.00 | do | | 130 |
| 406 | do | do | D-5 | 1890 | Bored, 8-inch | 103 | 94 | 150 | 38 | Wind | | | Domestic | | |
| 407 | A. W. Miller | do | D-5 | 1902 | Bored, 10-inch | 104 | 99 | 176 | 39 | Gas | 350.00 | 1,650.00 | Irrigation | | 125 |
| 408 | H. Lewis | do | D-5 | 1883 | Bored, 7-inch | 104 | 99 | 140 | 37 | Hand | | | Domestic | | |
| 409 | G. W. Tweedy | do | D-5 | 1899 | Bored, 4-inch | 105 | 100 | 155 | 33 | Wind | 300.00 | 150.00 | do | | |
| 410 | L. D. Tweedy | do | D-4 | 1900 | Bored, 12-inch | 118 | 110 | 698 | | Gas | *4,500.00 | | Irrigation | | 200 |
| 411 | do | do | E-5 | 1884? | Bored, 10-inch | 104 | 103 | 250? | 38 | Wind | | | Domestic | | |
| 412 | do | do | D-5 | 1903 | Bored, 5-inch | 109 | 101 | 145 | | Hand | 145.00 | | do | | |
| 413 | H. W. Wythe | do | D-4 | 1901 | Bored. 10-inch | 105 | 99 | 174 | | Wind, gas | 300.00 | 300.00 | Domestic; irrigation. | | 50 |
| 414 | Mrs. Wilbur Woods | do | D-4 | 1897 | Bored, 4-inch | 104 | 99 | 83 | | Hand | | | Not used | | |
| 415 | C. O. Humphreys | do | D-4 | | Bored, 2-inch | 111 | | 85? | 39 | Wind | | | Domestic; irrigation. | | |
| 416 | Mr. White | do | D-4 | 1901 | Bored, 12-inch | 112 | 107 | 530 | 31 | Hand | 1,600.00 | | Domestic | | |
| 417 | do | do | D-4 | | Bored, 2-inch | 112 | | 85? | | do | | | Not used | | |
| 418 | Samuel Martin | do | C-5 | | Bored, 7-inch | 105 | 105 | 160 | 39 | Artesian, gas | | | do | | |
| 419 | do | do | C-5 | | do | 105 | 105 | 160 | | Artesian | | | do | | |
| 420 | K. Swantek | do | C-5 | 1890? | Bored, 4-inch | 105 | 105 | 150? | | do | | | Domestic | | |
| 421 | Samuel Martin | do | C-5 | 1880 | Bored, 7-inch | 100 | 100 | 160 | 38 | Wind | 300.00 | | do | | |
| 422 | do | do | C-5 | 1880 | do | 98 | 98 | 160 | 41 | Artesian | 300.00 | | Irrigation | | 60 |
| 423 | do | do | C-5 | 1895? | do | 98 | 98 | 160 | 40 | do | | | do | | |
| 424 | William Lynch | do | C-6 | 1876 | Bored, 6-inch | 97 | 97 | 172 | 37 | do | 275.00 | | Domestic | | 6 |
| 425 | Mr. Kincaid | do | C-6 | 1896 | Bored, 4-inch | 93 | 90? | 180 | 37 | Hand | | | do | | |
| 426 | Fred Niel | do | D-6 | 1895? | Bored, 7-inch | 91 | | 180 | | Gas | 200.00 | | Irrigation | | |
| 427 | Mr. Carres | do | D-6 | | do | 90 | 84 | 180 | 38 | Hand | | | Stock | | |
| 428 | Frank Beck | do | D-6 | 1895? | Bored, 2-inch | 93 | | 170 | | do | | | Domestic | | |
| 429 | H. W. Lewis | do | C-6 | 1895 | Bored, 7-inch | 91 | 91 | 130 | 37 | Hand, artesian | 150.00 | | Irrigation; domestic. | | 25 |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 430 | Chas. Bates | San Antonio | C-6 | 1902 | Bored, 2-inch | 91 | 91 | 130 | 37 | Hand | $55.00 | | Domestic | |
| 431 | Lugo school district | do | C-6 | 1898 | do | 92 | 92 | 130 | 37 | Artesian | 55.00 | | do | |
| 432 | B. Eberly | do | C-6 | 1902 | do | 92 | 92 | 130 | 36 | Hand | 60.00 | | do | |
| 433 | E. W. Lewis | do | C-6 | 1875 | Bored, 7-inch | 91 | 91 | 130 | 38 | Artesian | 130.00 | | Domestic; irrigation. | 12 |
| 434 | do | do | C-6 | 1885 | do | 90 | 93 | 130 | | do | 130.00 | | Irrigation | 19 |
| 435 | Joseph Hohn | do | C-6 | 1894? | do | 90 | 90 | 130 | 41 | do | | | Domestic | |
| 436 | G. F. Daetweiler | do | C-6 | 1894 | do | 90 | 90 | 133 | 41 | do | | | Domestic; irrigation. | Small. |
| 437 | do | do | C-6 | | do | 90 | 90 | 130 | | do | | | Irrigation | Small. |
| 438 | John Eichholzer | do | B-6 | 1897? | Bored, 4-inch | 91 | 91 | 133 | 44 | do | | | Stock | |
| 439 | G. F. Daetweiler | do | B-6 | 1898? | do | 91 | 91 | 133 | 46 | do | | | do | |
| 440 | C. H. Sessions | do | B-5 | | Bored, 7-inch | 98 | 98 | 160 | | do | | | Irrigation | Small. |
| 441 | do | do | B-5 | 1898? | Bored, 10-inch | 99 | 99 | 160 | 51 | do | | | do | 2 |
| 442 | do | do | B-5 | 1898? | do | 99 | 99 | 160 | 51 | do | | | do | 2 |
| 443 | do | do | C-5 | | Bored, 12-inch | 95 | 95 | 380 | | do | | | Domestic | |
| 444 | do | do | B-6 | 1900? | do | 88 | 88 | 380 | 36 | do | | | Irrigation | |
| 445 | do | do | B-6 | 1900? | do | 88 | 88 | 380 | 35 | do | | | do | †40 |
| 446 | do | do | B-6 | | Bored, 6-inch | 85 | 85 | 140 | | do | | | Not used | |
| 447 | John Sinn | do | B-6 | 1901 | Bored, 7-inch | 88 | 88 | 325 | 32 | do | 590.00 | | Domestic; irrigation. | 7 |
| 448 | Frank Wall | do | C-6 | 1901 | Bored, 2-inch | 88 | 88 | 130 | 39 | do | 50.00 | | Domestic | 4 |
| 449 | James Nichols | do | C-6 | 1883? | Bored, 6-inch | 92 | 92 | 350 | 36 | Artesian, wind | | $125.00 | do | |
| 450 | E. Fickewirth | do | C-6 | 1883 | Bored, 2-inch | 91 | 91 | 130 | 38 | Artesian, hand | | | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 451 | W. B. Finch | do | C-6 | | do | 90 | 90 | | 37 | Hand | | | do | |
| 452 | Chas. Tibbetts | do | C-6 | 1887 | Bored, 4-inch | 87 | 87 | 140 | 37 | do | | | do | |
| 453 | H. Catey | do | C-6 | 1898 | Bored, 12-inch | 88 | 88 | 382 | 35 | Artesian | 1,200.00 | | Irrigation | †100 |
| 454 | do | do | C-6 | 1878? | Bored, 7-inch | 88 | 88 | 140 | | do | | | Not used | |
| 455 | Chas. Tibbetts | do | C-6 | 1891 | do | 87 | 87 | 140 | | do | | | | |
| 456 | H. Musselman | do | C-7 | 1885 | do | 85 | 85 | 145 | 38 | Wind | 200.00 | 175.00 | Domestic | |
| 457 | O. J. Williams | do | C-7 | 1885 | Bored, 9-inch | 85 | 84 | 140 | 36 | Hand | | | do | |
| 458 | J. L. Wininger | do | C-6 | 1880? | Bored, 7-inch | 87 | 84 | 140 | 36 | do | | | do | |
| 459 | Fred Daetweiler | do | C-7 | 1901 | Bored, 2-inch | 84 | 84 | 380 | 35 | Artesian | 150.00 | | do | |
| 460 | F. M. Kincaid | do | D-7 | 1902 | do | 83 | | 140 | 38 | Hand | 75.00 | | do | |
| 461 | J. O. Waite | do | D-7 | 1888? | Bored, 7-inch | 83 | 83 | 450 | 35 | Artesian | | | do | |
| 462 | John T. Daetweiler | do | C-6 | 1888 | do | 87 | 87 | 135 | 41 | do | 240.00 | | Irrigation | 60 |
| 463 | do | do | C-6 | 1878 | do | 87 | 87 | 135 | 41 | do | 300.00 | | do | 60 |
| 464 | G. Yeoman | do | C-7 | 1891 | do | 87 | 86 | 200 | 37 | Wind | | 125.00 | Stock; domestic | |
| 465 | do | do | C-7 | 1897 | Bored, 10-inch | 87 | 87 | 325 | 35 | Artesian | 600.00 | | Irrigation | 80 |
| 466 | Eureka Cooperative Creamery. | do | C-7 | 1894 | Bored, 4-inch | 85 | 85 | 130 | 35 | | | | Domestic | |
| 467 | M. P. McDonald | do | C-7 | 1887 | Bored, 7-inch | 84 | 84 | 130 | 37 | Artesian | | | do | 42 |
| 468 | do | do | C-7 | 1897 | do | 84 | 84 | 335 | 33 | do | 540.00 | | Irrigation | 50 |
| 469 | H. M. Williams | San Pedro | C-7 | 1894? | Bored, 3-inch | 82 | 82 | 140 | 33 | do | | | Domestic | |
| 470 | S. Stockwell | San Antonio | C-7 | | Bored, 7-inch | 80 | 80 | 145 | 38 | do | | | Not used | |
| 471 | Mrs. Hastings | San Pedro | C-7 | 1899 | do | 78 | 78 | 350 | 35 | do | 750.00 | | Irrigation | 40 |
| 472 | do | do | C-7 | 1895 | do | 71 | 71 | 135 | 40 | do | 500.00 | | Domestic | Small. |
| 473 | do | do | C-7 | 1895 | do | 71 | 71 | 135 | | do | 500.00 | | Not used | |
| 474 | M. Elfman | do | C-7 | 1897 | Bored, 2-inch | 77 | 77 | 250? | 33 | do | 150.00 | | Domestic; stock | Small. |
| 475 | N. L. McIntosh | do | C-7 | 1896 | Bored, 7-inch | 77 | 77 | 315 | | do | 500.00 | | Not used | 7 |
| 476 | Mrs. A. A. Williams | do | C-7 | 1894 | Bored, 2-inch | 78 | 78 | 350 | 33 | do | 555.00? | | Domestic | |
| 478 | R. B. Easley | do | C-7 | 1902 | Bored, 10-inch | 79 | | 150 | 35 | Wind | 250.00 | | do | |
| 479 | J. H. Easley | do | C-7 | 1891 | Bored, 3-inch | 81 | 81 | 320 | | Artesian | | | Not used | |
| 480 | A. W. Miller | do | C-7 | | Bored, 8-inch | 77 | | 150 | | | | | Irrigation | †85 |
| 481 | J. L. Johnson | do | C-8 | 1899 | Bored, 9½-inch | 71 | 71 | 400 | 33 | Artesian | 800.00 | | do | †40 |
| 482 | A. R. McIntosh | do | C-7 | 1898 | Bored, 2-inch | 78 | 75 | 80 | 41 | Hand | 40.00 | | Domestic | |
| 483 | F. Vennass | do | C-7 | 1880? | Bored, 7-inch | 75 | 75 | 150 | | Gas | 185.00 | | Irrigation | 65 |
| 484 | do | do | C-7 | 1897 | do | 74 | 74 | 150 | 37 | do | 150.00 | | do | 65 |
| 485 | do | do | B-7 | 1899 | do | 75 | 75 | 150 | 40 | Artesian | 150.00 | | do | 76 |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 486 | F. Walton | San Pedro | C-7 | 1899 | Bored, 7-inch | 74 | 74 | 150 | 39 | Artesian | $150.00 | | Irrigation | 19 |
| 487 | F. E. Stockwell | San Antonio | C-7 | 1883 | do | 83 | 83 | 148 | 41 | do | 250.00 | | do | †60 |
| 488 | do | do | C-6 | 1891 | do | 83 | 83 | 158 | 40 | do | 180.00 | | do | †60 |
| 489 | do | do | C-7 | 1881 | do | 82 | 82 | 147 | 40 | do | 250.00 | | do | |
| 490 | H. C. Carson | San Pedro | C-7 | 1888 | Bored, 6-inch | 77 | 77 | 163 | 39 | Hand, artesian | 200.00 | | Irrigation; stock | |
| 491 | L. Abbott | do | C-7 | 1885? | Bored, 7-inch | 80 | 80 | 150? | 42 | Artesian | 200.00 | | do | |
| 492 | E. Miller | do | C-7 | 1875? | do | 75 | 75 | 136 | 43 | do | 136.00 | | Domestic | Small. |
| 493 | Wm. McDivitt | do | B-7 | 1890 | do | 80 | 80 | 145 | | do | 150.00 | | Irrigation | 25 |
| 494 | do | do | B-7 | 1901 | Bored, 10-inch | 80 | 80 | 150 | 41 | do | 500.00 | | do | †25 |
| 495 | do | do | B-7 | 1901 | do | 78 | 78 | 150 | 41 | do | 500.00 | | do | 25 |
| 496 | do | do | B-7 | 1888 | Bored, 2-inch | 78 | 78 | 150 | 39 | Artesian, hand | 60.00 | | Stock; domestic | Small. |
| 497 | J. R. Hann | do | B-7 | 1902 | do | 77 | 77 | 233 | 39 | Artesian | 104.50 | | Domestic; irrigation. | 2 |
| 498 | J. S. Palmer | do | B-7 | 1883? | Bored, 7-inch | 76 | 76 | 260 | 33 | do | | | Domestic | |
| 499 | G. Palmer | do | B-8 | 1893 | Bored, 2-inch | 67 | 67 | 228 | | do | 100.00 | | Domestic; stock | Small. |
| 500 | J. A. McMillan | do | B-7 | 1901 | do | 75 | 75 | 220 | 34 | do | 100.00 | | Domestic; irrigation. | |
| 501 | R. H. Dinsmore | do | C-8 | 1881 | Bored, 7-inch | 71 | 71 | 130 | 42 | Hand | | | Domestic | |
| 502 | C. E. Wood | do | C-8 | 1899 | Bored, 2-inch | 73 | 73 | 310 | 34 | Artesian | 135.00 | | Domestic; irrigation. | 6 |
| 503 | A. Sloane | do | C-7 | 1900 | Bored, 9½-inch | 73 | 73 | 339 | 33 | do | 600.00 | | Irrigation | †50 |
| 504 | do | do | C-8 | 1898 | Bored, 3-inch | 70 | 70 | 275 | 33 | do | 135.00 | | Domestic | 12 |
| 505 | L. A. Leavitt & Co. | do | C-8 | 1894 | Bored, 7-inch | 68 | 68 | 290 | 35 | do | 300.00 | | Irrigation | |
| 506 | H. J. Mayo | do | B-8 | 1900 | do | 67 | 67 | 280 | 33 | do | 700.00 | | do | 20 |
| 507 | do | do | B-8 | 1900 | Bored, 2-inch | 68 | 68 | 280 | 33 | do | 300.00 | | Domestic | Small. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 508 | W. G. Legg | do | B-8 | 1890 | Bored, 4-inch | 70 | 70 | 260 | 34 | do | 200.00 | | do | |
| 509 | Mrs. J. Spencer | do | B-8 | 1896 | Bored, 2-inch | 70 | 70 | 160 | 37 | do | 100.00 | | do | |
| 510 | C. J. Clark | do | B-8 | | do | 69 | 69 | 200 | 35 | do | | | Domestic; stock | Small. |
| 511 | do | do | B-8 | | Bored, 3-inch | 70 | 70 | 200 | 35 | do | | | Irrigation | †10 |
| 512 | do | do | B-8 | | Bored- 7-inch | 70 | 71 | | 34 | do | | | Not used | |
| 513 | J. F. Norton | do | B-8 | 1895 | Bored, 3-inch | 69 | 69 | 230 | 35 | do | | | Domestic | Small. |
| 514 | L. Gully | do | B-8 | | Bored, 2-inch | 60 | 60 | | 34 | do | | | do | Small. |
| 515 | Chas. Wright | do | B-8 | 1897 | Bored, 6-inch | 67 | 67 | | 35 | do | | | Irrigation; domestic. | †30 |
| 516 | L Gully | do | B-8 | | Bored, 4-inch | 63 | 63 | | 35 | do | | | Irrigation | |
| 517 | Southern Pacific Co | do | B-8 | 1897 | Bored, 7-inch | 66 | 66 | 400 | 33 | do | | | Domestic | Small. |
| 518 | do | do | B-8 | 1888? | Bored, 2-inch | 67 | 67 | 180 | 33 | do | | | do | 3 |
| 519 | R. H. Wilson | do | B-8 | 1893 | Bored, 7-inch | 66 | 66 | 225 | 33 | Artesian, wind | 500.00 | | do | †1 |
| 522 | J. Malcom | do | B-8 | 1897 | do | 70 | 70 | 310 | 35 | Artesian | 375.00 | | Irrigation | 106 |
| 523 | Michael Ruffner | do | B-8 | 1895 | Bored, 2-inch | 67 | 67 | 193 | 33 | do | 100.00 | | Domestic | Small. |
| 524 | do | do | B-8 | 1868? | Bored, 6-inch | 67 | 67 | 216 | 33 | do | 900.00 | | do | 35 |
| 525 | do | do | B-8 | 1882? | do | 66 | 66 | 230 | 35 | do | 900.00 | | Domestic; stock | 18 |
| 529 | S. M. Bise | do | B-8 | 1899 | Hydraulic, 2-inch | 68 | 68 | 223 | 33 | do | 110.00 | | Stock | |
| 531 | Sarah I. Wigginton | do | B-8 | 1885? | Bored, 7-inch | 67 | 67 | 250 | 32 | Gas | 500.00 | | Domestic | 1 |
| 532 | J. D. McNiel | do | B-8 | 1898 | Bored, 2-inch | 70 | 70 | 258 | 34 | Artesian | 230.00 | | Domestic; irrigation | |
| 533 | Wm. Shamrak | do | B-8 | 1891 | Bored, 3-inch | 70 | 70 | 205 | 35 | Artesian, wind | 205.00 | $140.00 | Domestic | Small. |
| 534 | B. Walton | do | B-8 | | Bored, 2-inch | 70 | 70 | | 35 | Wind | 125.00 | | do | |
| 535 | Methodist Episcopal parsonage. | do | B-8 | 1878? | Bored, 7-inch | 70 | 70 | 100 | 34 | Artesian | | | do | |
| 536 | E. D. Morden | do | B-8 | 1897 | Hydraulic, 2-inch. | 68 | 68 | 210 | 35 | do | 87.50 | | do | Small. |
| 538 | Compton City school district. | do | B-8 | 1893 | Bored, 2-inch | 70 | 70 | 200? | 34 | do | 100.00 | | do | |
| 539 | Robert Shear | do | B-8 | 1895 | do | | | 255 | 33 | do | 125.00 | | do | |
| 540 | G. W. Rodgers | do | B-8 | 1894 | do | | | 225? | 35 | do | 100.00 | | do | |
| 541 | J. D. Gill | do | B-8 | 1900 | do | 67 | 67 | 200? | 35 | do | 100.00 | | do | |
| 542 | E. M. Yankee | do | B-8 | | do | 69 | 69 | 210? | 33 | do | 105.00 | | Domestic; irrigation. | |
| 543 | John Boyer | do | B-8 | 1903 | do | 70 | 70 | 381 | 34 | do | 202.50 | | Stock; domestic. | |
| 544 | H. M. Dillon | do | B-8 | 1895 | do | 69 | 69 | 200 | 33 | do | 110.00 | | Domestic | |
| 545 | Thos. J. Peachey | do | B-8 | 1897 | do | 69 | 69 | 160 | 33 | do | | | do | Small. |
| 546 | G. D. Barron | do | B-8 | | Bored, 7-inch | 71 | 71 | | 32 | Hand | | | do | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 547 | Robert Shear | San Pedro | A-7 | 1887 | Bored, 7-inch | 76 | 76 | 255 | | Artesian | | | Irrigation | |
| 548 | do | do | A-7 | 1895 | do | 75 | 75 | 255 | 33 | do | $250.00 | | do | †60 |
| 549 | B. F. Lasswell | do | A-8 | 1895 | Bored, 2-inch | 75 | 75 | 175 | 34 | Artesian, hand | 75.00 | | Domestic | Small. |
| 550 | John Stevens | do | A-8 | 1885 | Bored, 7-inch | 79 | 74 | 440 | 31 | Wind | 1,000.00 | | do | |
| 551 | O. S. Long | do | A-8 | | do | 80 | 77 | 175 | 35 | Hand | | | do | |
| 552 | A. C. Bird | do | A-8 | | do | 77 | 75 | 175 | 41 | Wind | | | do | |
| 553 | Mrs. Minnie Stuart | do | A-8 | 1885 | do | 81 | 76 | 160 | 33 | do | | | do | |
| 554 | A. C. Bird | do | A-7 | 1898? | Bored, 2-inch | 76 | 76 | 175 | 35 | Artesian, hand | | | do | |
| 555 | Chas. E. Marble | do | A-8 | 1870? | Bored, 7-inch | 84 | 78 | 160? | 34 | Wind | | | do | |
| 556 | C. A. Conklin | do | A-8 | 1873? | Bored, 6-inch | 87 | 70 | 160 | 36 | do | | | do | |
| 557 | H. C. Kelsea | do | A-7 | 1878 | Bored, 7-inch | 93 | 69 | 200 | 33 | Gas | 200.00 | $1,000.00 | Irrigation | 49 |
| 558 | Sam Flick | do | A-7 | 1887 | do | 93 | 68 | 200 | 34 | Wind | 200.00 | | Domestic | |
| 559 | P. Commeree | San Antonio | A-7 | 1899 | Bored, 10-inch | 92 | 72 | 240 | 33 | Gas | *1,000.00 | | Irrigation | †40 |
| 560 | O. Dehetre | San Pedro | A-7 | 1883 | Bored, 7-inch | 84 | 74 | 200 | 35 | Wind | | 125.00 | Domestic | |
| 561 | do | do | A-7 | 1888 | do | 84 | 71 | 200 | | | | | Not used | |
| 562 | T. H. Cressey | San Antonio | A-7 | 1886 | do | 84 | | 150 | 38 | Wind | 250.00 | | Domestic; irrigation. | |
| 563 | Benj. Lee | San Pedro | A-7 | 1899 | Hydraulic, 10-inch | 85 | 85 | 260 | 35 | Artesian | 425.00 | | Irrigation | Small. |
| 564 | do | do | A-7 | 1880? | Bored, 6-inch | 82 | 79 | 100 | 40 | Wind | | | Domestic | |
| 565 | M. C. Matthesen | do | A-7 | 1895 | Bored, 2-inch | 80 | 80 | 167 | 32 | Artesian | 67.00 | | Domestic; stock. | Small. |
| 566 | S. W. Imbler | do | A-7 | 1895 | do | 79 | 79 | 180 | 33 | do | 90.00 | | Domestic | |
| 567 | S. J. Hull | do | A-7 | 1878 | Bored, 7-inch | 79 | 79 | 160 | 34 | do | | | do | |
| 568 | D. M Crum | do | B-7 | 1885 | do | 78 | 78 | 209 | 34 | do | | | do | †7 |
| 569 | Mrs. Mary Harrison | do | B-7 | 1898 | Bored 12-inch | 78 | 78 | 254 | 33 | do | 500.00 | | Irrigation | 22 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 570 | Isaac Walton | do | B-7 | 1890? | Bored, 7-inch | 77 | 77 | 225? | 33 | do | | | do | | 2 |
| 571 | Mrs. M. Safstrom | do | B-7 | | Bored 2-inch | 72 | 72 | | 35 | do | | | Irrigation; domestic. | | Small. |
| 572 | J. Dimler | do | B-7 | 1902 | do | 69 | 69 | 253 | 35 | do | 100.00 | | Domestic | | Small. |
| 573 | C. Mealey | do | B-7 | 1888 | Bored, 4-inch | 75 | | 100 | 37 | Hand | 100.00 | | do | | |
| 574 | J. Kelso | do | B-7 | 1902 | Bored, 2-inch | 67 | 67 | 237 | 35 | Artesian | 115.00 | | do | | |
| 575 | John Flood | do | B-7 | | Bored, 4-inch | 68 | 68 | 260 | 37 | Hand | | | do | | |
| 576 | L. F. Stockwell | San Antonio | B-6 | 1878 | Bored, 7-inch | 78 | 78 | 525 | 33 | Artesian | | | Irrigation | | †3 |
| 577 | do | do | A-6 | 1896 | do | 79 | 79 | 500 | | do | 1,200.00 | | do | | †5 |
| 578 | Dr. A. M. McCulloh | do | B-7 | 1902 | Bored, 10-inch | 79 | 79 | 269 | 33 | do | 500.00 | | do | | †55 |
| 579 | do | do | B-7 | 1890? | Driven, 2-inch | 73 | 73 | 75 | | do | 35.00 | | Not used | | |
| 580 | Mrs. Banning | do | B-6 | | Bored, 7-inch | 81 | 81 | | 38 | do | | | Domestic; irrigation. | | |
| 581 | C. H. Sessions | do | B-6 | | do | 81 | 81 | 150? | | do | | | Stock | | |
| 582 | E. Northcote | do | B-6 | 1892? | Bored, 2-inch | 86 | 86 | | 41 | do | | | Domestic | | |
| 583 | Mr. Brown | do | B-6 | | Bored, 4-inch | 89 | 89 | | 41 | do | | | do | | |
| 584 | E. E. Galbreth | do | B-5 | | Bored, 7-inch | 93 | 93 | 64 | 47 | do | | | do | | Small. |
| 585 | Omri Bullis | do | B-6 | 1902 | Bored, 2-inch | 91 | 91 | 40 | 51 | do | 42.00 | | Domestic; irrigation. | | |
| 586 | do | do | B-5 | 1883 | Bored, 7-inch | 93 | 93 | 82 | 47 | do | 80.00 | | Stock | | Small. |
| 587 | E. E. Galbreth | do | B-5 | | do | 94 | 94 | 72 | 45 | do | | | Domestic | | Small. |
| 588 | L. Snodgrass | do | B-5 | 1897 | Bored, 8-inch | 98 | 98 | 400? | 42 | Artesian, gas | 500.00 | | Irrigation | | |
| 589 | F. Hoppe | do | B-5 | 1883 | Bored, 6-inch | 99 | 99 | 85 | 49 | Artesian | | | Stock | | Small. |
| 590 | do | do | B-5 | 1883 | Bored, 5-inch | 105 | 105 | 85 | 47 | do | | | do | | 2 |
| 591 | A. Gunn | do | B-5 | | Bored, 6-inch | 97 | 97 | 96 | 51 | do | | | Domestic | | †6 |
| 592 | Sessions & Collins | do | B-5 | | Bored, 7-inch | 100 | 100 | 100? | | do | | | Stock | | 2 |
| 593 | do | do | B-5 | | Bored, 5-inch | 100 | 100 | 130? | 49 | do | | | do | | Small. |
| 594 | Unknown | do | B-5 | 1880 | Bored, 7-inch | 103 | 103 | 135 | 40 | do | 300.00 | | do | | Small. |
| 595 | Mr. Gilky | do | C-5 | 1901 | do | 100 | 100 | 150 | 35 | do | 200.00 | | Irrigation | | 12 |
| 596 | Robert Tweedy | do | B-5 | 1896 | Bored, 4-inch | 107 | 107 | 90 | 48 | Wind | 75.00 | 300.00 | Domestic | | |
| 597 | James Tweedy | do | B-4 | 1902 | do | 116 | 116 | 105 | 40 | do | 81.00 | 72.00 | Stock | | |
| 598 | Mrs M. Tweedy | do | C-4 | 1893 | Bored, 6-inch | 116 | 116 | 130 | 38 | Artesian, wind | 150.00 | 35.00 | do | | Small. |
| 599 | Thos. Tweedy | do | B-4 | 1902 | Bored, 4-inch | 118 | 118 | 106 | 40 | Hand | 81.00 | | do | | |
| 600 | Robert Tweedy | do | C-4 | 1902 | do | 114 | 114 | 105 | 38 | Wind | 81.00 | 75.00 | Domestic; stock | | |
| 601 | J. E. Tweedy | do | C-4 | 1893 | Bored, 7-inch | 119 | 118 | 125 | 38 | Artesian, hand | 100.00 | 5.00 | Stock; domestic | | |
| 602 | C. Snodgrass | do | B-4 | 1901 | Bored, 10-inch | 113 | 110 | 125 | 40 | Gas | 200.00 | | Irrigation | | †60 |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 603 | C. Snodgrass | San Antonio | B-4 | 1880 | Bored, 6-inch | 112 | 112 | 90 | 42 | Artesian | $100.00 | | Domestic | Small. |
| 604 | do | do | A-4 | 1883 | Bored, 7-inch | 111 | 111 | 96 | | do | 100.00 | | Irrigation | |
| 605 | Phil. M. Crockett | do | B-4 | 1893 | Bored, 4-inch | 120 | 116 | 79 | 52 | Wind | | $200.00 | Domestic; irrigation. | |
| 606 | do | do | A-4 | 1893 | Bored, 7-inch | 113 | 112 | 200 | 38 | Artesian | | | Irrigation | |
| 607 | Mrs. Antoni | do | B-4 | 1893 | do | 120 | 119 | 113 | 41 | do | | | Domestic; irrigation. | |
| 608 | do | do | A-4 | 1895 | Bored, 10-inch | 116 | 115 | 104 | 40 | do | | | | |
| 609 | T. A. Tweedy | do | B-4 | 1888 | Bored, 6-inch | 123 | 118 | 140 | 45 | Wind | | 200.00 | Domestic | |
| 610 | C. F. Wood | do | A-7 | 1891 | Bored, 7-inch | 82 | 82 | 238 | 35 | do | | | Irrigation; domestic. | |
| 611 | F. L. Walton | do | A-7 | 1900 | Bored, 10-inch | 85 | 83 | 240 | 37 | | 500.00 | | Irrigation | |
| 612 | Mrs. Botiyear | do | A-7 | 1890? | Bored, 6-inch | 85 | 85 | 225 | 37 | Artesian, hand | | | Domestic; irrigation. | |
| 613 | W. C. Walton | do | A-6 | 1895 | Bored, 2-inch | 87 | 86 | 228 | 37 | Wind | 110.00 | 150.00 | Domestic | |
| 614 | J. E. Lodge | do | A-6 | | Bored, 7-inch | 88 | 87 | 225? | 32 | | | | Not used | |
| 615 | D. H. Drinkerhoff | do | A-6 | 1900 | do | 91 | 90 | 243 | | Gas | 300.00 | 750.00 | Irrigation | 100 |
| 616 | Mrs. Mary Banning | do | A-6 | 1883 | do | 90 | 90 | 252 | 34 | Wind | 300.00 | | Domestic | |
| 617 | E. S. Gunby | do | A-6 | 1888 | do | 94 | 94 | 250 | | Gas | 500.00 | 600.00 | Irrigation | 60 |
| 618 | do | do | A-6 | 1890? | do | 93 | 93 | 325? | 35 | | | | Not used | |
| 619 | Mrs. Westem | do | A-6 | 1878 | do | 92 | 92 | 100 | 45 | Wind | 100.00 | 150.00 | Domestic; stock. | |
| 620 | do | do | A-6 | 1878 | do | 93 | 93 | 500 | 33 | | 1,000.00 | | | |
| 621 | do | do | A-6 | 1878 | do | 92 | 92 | 100 | | Artesian | 100.00 | | Stock | Small. |
| 622 | Wm. Stahl | do | A-6 | | Bored, 6-inch | 93 | 93 | 250 | 38 | | | | Domestic; irrigation. | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 623 | W. F. Ruoff | do | A-6 | 1887 | Bored, 7-inch | 94 | 93 | 100 | 48 | Hand | | | Domestic | |
| 624 | J. C. Reece | do | A-5 | 1890? | do | 94 | 93 | 225 | 40 | do | | | Domestic; irrigation | |
| 625 | M. MacFarland | do | A-5, 6 | | Bored, 4-inch | 98 | 93 | 90 | 44 | Wind | 50.00 | 150.00 | Domestic | |
| 626 | Mrs. J. M. Avila | do | A-5 | 1883 | Bored, 7-inch | 96 | 96 | 85 | 45 | Artesian | | | do | |
| 627 | Jesus Leon | do | A-5 | 1891 | Bored, 6-inch | 97 | 97 | 85 | 45 | do | 85.00 | | Domestic; irrigation. | Small. |
| 628 | C. W. Rice | do | A-5 | 1892 | Bored, 7-inch | 97 | 97 | 80 | 46 | do | 80.00 | | Irrigation | 2 |
| 629 | Mrs. F. Talamantos | do | A-5 | | do | 100 | 95 | 80 | 41 | Hand | 75.00 | | | |
| 630 | Strong & Nickinson | do | A-5 | | do | 102 | 94 | 72 | 38 | do | 70.00 | | Domestic | |
| 631 | do | do | A-5 | 1897 | Bored, 10-inch | 102 | 103 | 400 | 25 | Artesian | | | Not used | |
| 632 | do | do | A-5 | 1890? | Bored, 4-inch | 100 | 101 | 75 | 49 | do | 75.00 | | Stock | Small. |
| 633 | do | do | A-5 | 1897 | Bored 10-inch | 100 | 101 | 400 | 25 | do | | | do | Small. |
| 634 | do | do | A-5 | 1897 | Bored. 7-inch | 100 | 101 | 400 | 25 | do | | | do | Small. |
| 635 | J. G. Bellew | do | A-5 | 1882 | do | 100 | 100 | 73 | 49 | do | 100.00 | | Stock; irrigation. | 8 |
| 636 | do | do | A-5 | 1900 | do | 98 | 98 | 75 | 50 | do | 100.00 | | Irrigation | 17 |
| 637 | do | do | A-5 | 1898 | do | 99 | 99 | 75 | 49 | do | 100.00 | | do | 12 |
| 638 | Isaac Walton | do | A-5 | 1899 | Bored, 4-inch | 100 | 100 | 75 | 49 | do | 50.00 | | Domestic | Small. |
| 639 | G. W. Kennedy | do | A-5 | 1888 | Bored, 7-inch | 101 | 101 | 80 | 51 | do | 100.00 | | do | Small. |
| 640 | Mr. Wood | do | A-5 | | Bored, 4-inch | 102 | 102 | 75 | 52 | do | | | do | |
| 641 | Alfred Bellew | do. | A-5 | | Bored, 7-inch | 105 | 105 | 75 | 52 | do | | | do | |
| 642 | Mr. Isaac Walton | do | A-5 | | do | 105 | 105 | 75 | 52 | do | 100.00 | | do | Small. |
| 643 | do | do | A-5 | 1895? | do | 105 | 105 | 80 | 52 | do | 100.00 | | Irrigation | †10 |
| 644 | do | do | A-5 | 1895? | do | 105 | 105 | 80 | 53 | do | 100.00 | | do | †10 |
| 645 | do | do | A-5 | 1895? | do | 104 | 104 | 80 | 52 | do | 100.00 | | do | †10 |
| 646 | Mr. Forthman | do | A-5 | | Bored, 8-inch | 107 | 107 | 80 | 52 | Artesian, wind | | | Domestic | Small. |
| 647 | do | do | A-5 | | Bored, 7-inch | 109 | 109 | 85 | 52 | Artesian | | | Irrigation | |
| 648 | do | do | A-4, 5 | | Bored, 9½-inch | 109 | 109 | 85 | 51 | do | | | do | |
| 649 | do | do | A-4, 5 | | do | 108 | 108 | 82 | 52 | do | | | do | |
| 650 | do | do | A-4, 5 | | do | 107 | 107 | 80 | 48 | | | | do | |
| 651 | Philip Valenzude | do | A-4 | 1887 | | 110 | 107 | 85 | 50 | Hand | 100.00 | | Domestic | |
| 652 | Tajantaschool district | do | A-4 | 1888? | Bored, 7-inch | 113 | 113 | 85 | 49 | Artesian | 100.00 | | do | Small. |
| 653 | F. M. Anderson | do | A-4 | 1890 | do | 113 | 113 | 84 | 51 | Wind | 100.00 | | do | |
| 654 | do | do | A-4 | 1891 | do | 113 | 110 | 450 | 33 | | | | Irrigation | |
| 655 | do | do | A-4 | 1890 | do | 116 | 114 | 84 | 45 | | | | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 656 | Thos. Duggan | San Antonio | A-4 | 1890? | Bored, 4-inch | 115 | 115 | 84 | 50 | | | | Domestic; irrigation. | |
| 657 | C. D. Barklew | do | A-5 | | do | 111 | 110 | 80 | 44 | Wind | | | Domestic | |
| 658 | Pacific Electric R. R. Co. | do | A-4 | | Bored, 7-inch | 112 | 112 | 85 | 51 | Wind, electricity. | | | do | |
| 659 | Geo. J. Ley | do | A-4 | 1902 | Hydraulic, 2-inch | 113 | 112 | 90 | 51 | Hand | $49.00 | | do | |
| 660 | do | do | A-4 | 1883 | Bored, 5-inch | 115 | 113 | 74 | 51 | do | | | do | |
| 661 | do | do | A-4 | 1883 | Bored, 6-inch | 115 | 113 | 74 | | do | | | Stock; irrigation | |
| 662 | Mrs. Lena Diller | do | A-5 | 1897 | Bored, 7-inch | 109 | 109 | 72 | 51 | Gas | | | Irrigation | |
| 663 | Mr. Mackley | do | A-4, 5 | 1895? | Bored, 5-inch | 112 | 111 | 85 | 51 | Hand | | | Domestic | |
| 664 | F. E. Ramsaur | do | A-5 | 1887 | Bored, 7-inch | 106 | 106 | 72 | 48 | Artesian | | | Stock | |
| 665 | do | do | A-5 | 1900 | Bored, 10-inch | 106 | 106 | 69 | 43 | do | | | do | Small. |
| 666 | do | do | A-4 | 1888? | Bored, 7-inch | 117 | 115 | 78 | 51 | Hand | | | Domestic | |
| 667 | W. F. Ruoff | do | A-4 | 1887 | do | 118 | 116 | 84 | 47 | Wind | 110.00 | $75.00 | Irrigation; domestic. | |
| 668 | do | do | A-4 | 1893 | do | 117 | 117 | 72 | 51 | Artesian | 85.00 | | Irrigation | Small. |
| 669 | Chas. Lash | do | A-4 | 1888 | do | 116 | 114 | 150 | 51 | Wind | | 100.00 | Not used | |
| 670 | do | do | A-4 | 1882 | do | 115 | 114 | 86 | 50 | | | | do | |
| 671 | David Elcoat | do | A-4 | 1896 | do | 122 | 117 | 90 | 49 | | 100.00 | | Irrigation | |
| 672 | Jacob Bosshard | do | A-4 | 1888 | do | 127 | 121 | 160 | | | 200.00 | | Not used | |
| 673 | Mrs. E. Crane | do | A-4 | 1889 | Bored, 4-inch | 127 | 120 | 105 | | Hand | | | Domestic | |
| 674 | Mr. Stege | do | A-4 | | Bored, 7-inch | 125 | 119 | 90 | 49 | do | 100.00 | | do | |
| 675 | J. F. Donohue | do | A-4 | 1884 | do | 124 | 118 | 100 | 49 | Wind | | | do | |
| 676 | S. H. Minor | do | A-4 | 1890 | Bored, 3-inch | 125 | 120 | 95 | 46 | do | 50.00 | 150.00 | Irrigation; domestic. | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 677 | do | do | A-4 | 1880 | Bored, 7-inch | 127 | 122 | 105 | 53 | Hand | 125.00 | | Stock | | |
| 678 | H. F. Starks | do | A-4 | 1898 | do | 122 | 117 | 123 | 40 | Wind | 130.00 | 225.00 | Domestic; irrigation. | | |
| 679 | do | do | A-4 | 1898 | Bored, 10-inch | 123 | 118 | 118 | 49 | | 150.00 | | Not used | | |
| 680 | do | do | A-4 | 1888 | Bored, 7-inch | 121 | 117 | 100 | 49 | | 150.00 | | Stock | | |
| 681 | do | do | A-4 | 1888 | do | 118 | 115 | 100 | 40 | | 150.00 | | Not used | | |
| 682 | Mr. Gilmore | do | A-4 | 1887? | do | 125 | 120 | 105 | 52 | Hand | | | Domestic | | |
| 683 | H. D. Merrill | do | A-4 | 1883 | do | 130 | 121 | 130 | 52 | do | 140.00 | | do | | |
| 684 | do | do | A-4 | 1903 | do | 129 | 120 | 70 | 45 | | 100.00 | | Not used | | |
| 685 | A. E. Putney | do | A-3,4 | 1887 | do | 132 | 122 | 135 | 46 | Compressed air. | 200.00 | 1,000.00 | Irrigation | | 70 |
| 686 | J. W. Kent | do | A-4 | | do | 131 | 121 | 120 | 53 | Gas | 175.00 | 1,000.00 | Irrigation; domestic. | | 70 |
| 687 | Mrs. Emma Crane | do | A-4 | 1888 | do | 130 | 121 | 120 | 75 | do | | 1,000.00 | Irrigation | | |
| 688 | Mr. Joseph Burkhart | do | A-3 | | Bored, 10-inch | 134 | 121 | 165 | 33 | | | | Not used | | |
| 689 | do | do | A-3 | | Bored, 7-inch | 133 | 121 | | 52 | Wind | | 60.00 | Stock | | |
| 690 | do | do | A-3 | | do | 131 | 122 | 85 | 28 | | | | Not used | | |
| 691 | do | do | A-3 | | do | 129 | 121 | | 73 | | | | do | | |
| 692 | do | do | A-3 | | do | 131 | 121 | 120 | 25 | | | | do | | |
| 693 | F. X. Eberle | do | A-4 | 1885 | do | 126 | 120 | 130 | 51 | Hand | | | Domestic | | |
| 694 | L. M. Russell | do | A-3 | 1882 | do | 137 | 127 | 109 | 53 | do | 100.00 | | do | | |
| 695 | M. Inglis | do | A-3 | 1902 | Bored, 6-inch | 138 | 124 | 106 | | Wind | 120.00 | 233.00 | Domestic; irrigation. | | |
| 696 | A. Inglis | do | A-3 | 1882 | Bored, 7-inch | 139 | 124 | 109 | 54 | do | 125.00 | 200.00 | Domestic | | |
| 697 | G. A. Nadeau | do | A-3 | 1873 | do | 139 | 122 | 150 | 52 | | 200.00 | | Not used | | |
| 698 | do | do | A-3 | 1875 | do | 138 | 132 | 150 | | Wind | 200.00 | 150.00 | Stock | | |
| 699 | do | do | A-3 | 1875 | do | 144 | 125 | 155 | | | 200.00 | | Not used | | |
| 700 | Mrs. G. Rutan | do | A-3 | 1902 | do | 145 | 126 | 160 | 53 | Wind | 200.00 | 150.00 | Domestic | | |
| 701 | Southern Pacific Co. | do | A-3 | 1885 | Bored, 6-inch | 142 | 124 | 149 | 52 | Gas | 150.00 | 500.00 | Engines | | 11 |
| 702 | Mrs. E. A. Stout | do | A-3 | | Bored, 7-inch | 141 | 124 | 127 | 49 | Hand | | | Domestic | | |
| 703 | Fred Shores | do | A-3 | 1903 | do | 138 | 124 | 85 | 39 | do | 105.00 | | do | | |
| 704 | S. F. Estell | do | A-3 | 1891 | Bored, 2-inch | 141 | 125 | 90 | 51 | do | 45.00 | | Irrigation; domestic. | | |
| 705 | Robert Thaxter | do | A-3 | 1897 | Bored, 7-inch | 147 | 125 | 95 | 63 | Wind | 125.00 | 200.00 | Domestic | | |
| 706 | A. Aylmore | do | A-2 | 1897? | do | 154 | 128 | 103 | 61 | do | | 200.00 | do | | |
| 707 | E. F. Smith & Co. | do | A-2 | 1898? | Bored, 2-inch | 153 | | | | do | | 200.00 | Not used | | |
| 708 | G. A. Blakeslee | do | A-2 | 1885 | Bored, 7-inch | 158 | 128 | 98 | 68 | Hand | 120.00 | 5.00 | Domestic | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 709 | Z. L. Parmlee | San Antonio | A-2 | | Bored, 7-inch | 161 | 133 | 75 | 67 | Wind | | $200.00 | Domestic | |
| 710 | I. H. Bryson | do | A-2 | 1897 | do | 167 | 130 | 92 | 46 | do | $125.00 | 200.00 | do | |
| 711 | Z. S. Spalding | do | A-2 | 1899 | Bored, 10-inch | 162 | 131 | 100 | 91 | do | 125.00 | 200.00 | do | |
| 712 | Joe Dutcher | do | A-2 | | Bored, 2-inch | 165 | 132? | 75 | 85 | do | 40.00 | 200.00 | do | |
| 713 | Mr. C. Dutcher | do | A-2 | 1902 | Bored, 7-inch | 167 | 132 | 100 | 75 | do | 120.00 | 200.00 | do | |
| 714 | do | do | A-2 | 1888 | do | 168 | | 60 | 70 | do | 60.00 | 200.00 | Stock | |
| 715 | Chas. Porter | do | A-2 | 1888 | do | 169 | 136 | 61 | 78 | Hand | 60.00 | | Domestic | |
| 716 | Ed Trapp | do | A-2 | 1901 | do | 170 | | 75 | 68 | Wind | 70.00 | 350.00 | do | |
| 717 | F. Ahrens | do | A-2 | 1902 | Bored, 1½-inch | 173 | 133 | 60 | | do | 20.00 | 180.00 | do | |
| 718 | do | do | A-1 | 1900 | Driven, 2-inch | 175 | | 63 | 66 | Hand | 20.00 | | do | |
| 719 | Nadeau Town Site Improvement Co. | Los Angeles city | A-1 | | Bored, 7-inch | 179 | | 100 | 49 | Wind | | 225.00 | do | |
| 720 | Los Angeles Land Co. | do | B-7 | | do | 185 | 136 | 100? | 51 | Hand | | | do | |
| 721 | Mrs. Thompson | do | A-1 | 1890? | do | 175 | | | 70 | Wind | | 250.00 | do | |
| 722 | H. Cornelson | do | A-1 | 1900 | Driven, 2-inch | 181 | 151? | 70 | 62 | Hand | 40.00 | | do | |
| 723 | Andrew Daneri | do | A-1 | 1889 | Bored, 7-inch | 188 | 143 | 75 | 56 | Wind | 75.00 | 200.00 | do | |
| 724 | J. Gibbs | do | A-1 | 1891 | do | 190 | 142 | 66 | 52 | Hand | 90.00 | | do | |
| 725 | R. S. Smith | do | A-1 | | Bored, 6-inch | 188 | 140 | 63 | 53 | Wind | 75.00 | 225.00 | do | |
| 726 | I. Gibbs | do | A-1 | 1881 | Bored, 7-inch | 191 | 142? | 65 | 53 | do | 80.00 | 250.00 | do | |
| 727 | J. T. Gitchell | do | A-1 | 1892 | do | 194 | 140 | 63 | 52 | do | 85.00 | 145.00 | do | |
| 728 | P. W. Sams | do | A-1 | 1888 | Bored, 6-inch | 196 | 137 | 65 | 53 | Wind, horse-power. | 80.00 | 200.00 | do | |
| 729 | J. W. Simpson | do | A-1 | 1902 | Bored, 7-inch | 195 | 130 | 85 | 52 | Wind | 200.00 | 200.00 | Domestic; irrigation. | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 730 | H. A. Moore | do | A-1 | 1884 | do | 192 | 135 | 68 | 52 | do | | | Domestic | | |
| 731 | John W. Mills | do | A-1 | 1900 | do | 193 | | 70 | 50 | Gas | 25.00 | 125.00 | Domestic; irrigation. | | |
| 732 | Mrs. M. J. Brewster | do | A-1 | 1899 | do | 196 | 154 | 68 | 52 | Hand | 75.00 | | Domestic | | |
| 733 | Mrs. J. L. Adams | do | A-1 | | do | 196 | | | 53 | Wind | | 150.00 | do | | |
| 734 | S. S. Harper | do | A-1 | 1903 | do | 191 | 136 | 91 | 48 | Gas | 110.00 | 150.00 | do | | |
| 735 | Pacific Electric R. R. Co. | do | A-1 | 1893 | do | 194 | 136 | 90 | 52 | Wind | 110.00 | 200.00 | do | | |
| 736 | Mr. Carasosa | do | A-1 | | Bored, 3-inch | 189 | | | 51 | do | | | do | | |
| 737 | Chas. M. More | do | A-1 | 1899 | Bored, 9-inch | 193 | 141 | 192 | 47 | Compressed air | 700.00 | | Not used | | |
| 738 | Moore Bros | do | B-1 | 1900 | Bored, 12-inch | 193 | 138 | 226 | 33 | do | 700.00 | | Irrigation | 55 | |
| 739 | do | San Antonio | B-1 | 1901 | do | 193 | 138 | 226 | 33 | do | 700.00 | | do | 55 | |
| 740 | Mr. Anderson | Los Angeles city | A-1 | 1898? | Bored, 7-inch | 189 | 136 | 75 | 46 | Wind | 75.00 | 150.00 | Domestic | | |
| 741 | Moore Bros | San Antonio | B-1 | 1902 | do | 186 | 135 | 74 | 41 | Hand | 75.00 | | do | | |
| 742 | Maria Alvaris | do | B-1 | 1891 | do | 192 | 137 | 62 | 43 | do | 80.00 | | do | | |
| 743 | E. O. McClure | Los Angeles city | A-1 | 1898 | Bored, 10-inch | 192 | 143 | 440 | 41 | Wind | 960.00 | 150.00 | do | | |
| 744 | John Moore | do | A-1 | 1901 | Bored, 7-inch | 191 | 140 | 78 | 44 | Gas | 200.00 | 315.00 | Stock; domestic. | 1 | |
| 745 | J. Furlong | do | A-1 | 1900 | Bored, 6-inch | 183 | 133 | 60 | 41 | Hand | | | Domestic | | |
| 746 | do | do | A-1 | 1899 | Bored, 7-inch | 183 | 133 | 70 | 45 | do | 75.00 | | Not used | | |
| 747 | Furlong Bros | do | A-1 | 1901 | do | 186 | 126? | 68 | 45 | Wind | 80.00 | 85.00 | Domestic | | |
| 748 | E. P. Merritt | do | A-1 | 1885? | do | 186 | 134 | 70 | 40 | do | 80.00 | 200.00 | do | | |
| 749 | J. G. White | do | A-1 | 1883 | do | 182 | 132? | 70 | 45 | do | 75.00 | 175.00 | do | | |
| 750 | N. J. White | do | A-1 | 1902 | do | 182 | 133 | 62 | 42 | Hand, gas | 120.00 | | Domestic; irrigation. | | |
| 751 | Pacific Electric R. R. Co. | do | A-1 | 1892 | do | 182 | 133 | 65 | 42 | Wind | 75.00 | 150.00 | Domestic | | |
| 752 | E. M. Landon | San Antonio | A-2 | 1888? | do | 179 | | 90 | | do | 100.00 | | do | | |
| 753 | Mr. Peralta | do | A-1 | 1901 | do | 180 | 135 | 64 | 41 | Hand | 80.00 | | do | | |
| 754 | Caytano C. Quijada | do | A-1 | 1901 | do | 180 | 135 | 74 | 42 | Wind | 100.00 | | do | | |
| 755 | Nellie E. Prescott | do | A-2 | 1901 | do | 178 | 135 | 83 | 40 | do | 85.00 | 235.00 | do | | |
| 756 | Mrs. D. L. Page | do | A-1 | 1900 | do | 179 | 133 | 85 | 36 | do | | | Domestic; irrigation. | | |
| 757 | John T. Holly | do | A-2 | 1893 | Bored, 4-inch | 178 | | 86 | 41 | Hand | 100.00 | | Domestic | | |
| 758 | Mr. Reed | do | A-2 | 1895 | Bored, 7-inch | 178 | | 75? | 40 | do | 80.00 | | do | | |
| 759 | J. C. Higgins | do | A-2 | 1899 | do | 177 | | 80 | 43 | Wind | 100.00 | 100.00 | | | |
| 760 | Amer. Agr. Chem. Co. | do | A-2 | 1898 | Bored, 10-inch | 176 | 134 | 90 | 35 | Steam | | | Factory | | |
| 761 | E. G. Underher | do | A-2 | 1883 | Bored, 7-inch | 173 | 133 | 85? | 53 | Hand | | | Domestic | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 762 | John B. Morrison | San Antonio | A-2 | 1886 | Bored, 7-inch | 173 | 135 | 89 | 40 | Wind | $75.00 | | Domestic | |
| 763 | Mrs. E. S. Morrison | do | A-2 | 1884 | do | 171 | 134 | 88 | 41 | do | 80.00 | $125.00 | do | |
| 764 | Mrs. Paris | do | A-2 | 1897 | do | 169 | 134 | 90 | 38 | do | 90.00 | | do | |
| 765 | Geo. Jones | do | A-2 | 1884 | do | 166 | 131 | 120 | 38 | do | 125.00 | 150.00 | do | |
| 766 | John Booth | do | A-2 | 1891 | do | 165 | 130 | 60? | 40 | do | | | do | |
| 767 | Mrs. O. J. Nichols | do | A-2 | 1887 | do | 166 | 132 | 60 | 48 | Hand | 70.00 | 2.50 | do | |
| 768 | Miss B. Morrison | do | A-2 | 1884 | do | 165 | 132 | 109 | 42 | Wind | 140.00 | | do | |
| 769 | Mr. Ingalls | do | A-2 | 1888? | do | 162 | 127 | 63 | 42 | Hand | | | do | |
| 770 | M. J. Innes | do | A-2 | 1900 | do | 159 | 128 | 100 | 41 | Wind | 100.00 | 180.00 | Domestic; irrigation. | |
| 771 | Mrs. Marie Kramer | do | A-2 | 1890? | do | 158 | 128 | 83 | 42 | do | | | Domestic | |
| 772 | H. B. Blakeley | do | | 1883 | do | 159 | 129 | 69 | 42 | do | *315.00 | | do | |
| 773 | H. M. Vance | do | A-2 | 1883 | Bored, 4-inch | 158 | 128 | 69 | 47 | do | 65.00 | 180.00 | Domestic; irrigation. | |
| 774 | do | do | A-2 | 1897 | Bored, 7-inch | 159 | 128 | 68 | 46 | do | 70.00 | 175.00 | Irrigation | |
| 775 | Methodist Episcopal parsonage. | do | A-2 | 1885 | do | 159 | 128 | 70 | 105 | Hand | | | Domestic | |
| 776 | J. F. Ahlstrom | do | A-2 | 1888 | do | 160 | 127 | 70? | 53 | Wind | | | do | |
| 777 | Mrs. Blakesley | do | A-2 | | do | 157 | 128 | 75? | | Hand | | | do | |
| 778 | Florence school district. | do | A-2 | 1883 | do | 157 | 127 | 75 | 53 | Wind | 75.00 | 200.00 | do | |
| 779 | F. E. Cleland | do | A-2 | 1883 | do | 157 | 127 | 78 | 56 | do | 80.00 | 200.00 | do | |
| 780 | Alfred Lane | do | A-2 | 1893 | do | 157 | 127 | 84 | 47 | Gas | | | Domestic; irrigation. | 35 |
| 781 | Mrs. Clark | do | A-2 | 1890 | do | 157 | 127 | 85? | 42 | Wind | | 150.00 | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 782 | Oliver Foster | do | A-2 | 1888? | do | 160 | 120 | 80 | 42 | do | 80.00 | 200.00 | do | | |
| 783 | Mrs. B. A. Clark | do | B-2 | 1903 | do | 160 | 120 | 95 | 38 | do | 95.00 | 70.00 | Domestic; irrigation. | | |
| 784 | J. Cosgrove | do | A-2 | 1902 | Bored, 5-inch | 157 | 122? | 76 | 43 | Gas | 65.00 | | Domestic | | |
| 785 | Mr. Bixby | do | A 3 | 1888? | Bored, 7-inch | 153 | 128 | 52 | 52 | Wind | | | do | | |
| 786 | Edward Alvares | do | A-3 | 1902 | do | 149 | 127 | 85 | | do | 85.00 | 70.00 | do | | |
| 787 | E. Reiman | do | A-3 | | Driven, 2-inch | 148 | 126 | 80 | | do | | | do | | |
| 788 | R. Nadeau | do | A-2 | 1900 | Bored, 10-inch | 155 | 124 | 87 | | Gas | 310.00 | 1,500.00 | Irrigation | 60 | |
| 789 | do | do | A-2 | 1883 | Bored, 7-inch | 155 | 116 | 80 | 49 | Wind | 85.00 | | Domestic | | |
| 790 | Mrs. R. B. Durfee | do | A-3 | 1885 | do | 147 | 129 | 500 | 33 | do | | | do | | |
| 791 | Mrs. A. A. Lipsey | do | A-3 | 1894 | Bored, 2-inch | 144 | 128 | 92 | 47 | do | 45.00 | 125.00 | do | | |
| 792 | Mrs. Cox | do | A-2 | | do | 145 | | 60 | 65 | Hand | 30.00 | | Stock | | |
| 793 | W. S. Barlowe | do | B-3 | 1902 | Bored, 5-inch | 143 | 126 | 30 | | do | | | do | | |
| 794 | Mrs. F. Winters | do | B-3 | 1901 | Bored, 7-inch | 143 | 129 | 81 | 49 | do | 85.00 | | Domestic | | |
| 796 | A. Huston | do | B-3 | 1902 | Bored, 5-inch | 143 | 130 | 25 | 70 | do | 25.00 | | do | | |
| 797 | J. Marsh | do | | 1899 | Bored, 2-inch | 144 | | 75 | 48 | do | | | do | | |
| 798 | S. C. Darby | do | B-3 | 1891 | Driven, 2-inch | 142 | | 90 | 52 | do | 45.00 | | do | | |
| 799 | F. M. Fulston | do | B-2 | 1900 | Bored, 7-inch | 167 | | 90 | 39 | Wind | | 200.00 | Domestic; irrigation. | | |
| 800 | W. M. Patterson | do | A, B-2 | 1897 | do | 168 | 133 | 90 | 39 | do | 100.00 | 200.00 | do | | |
| 801 | Michael Cudahy | do | B-2 | 1899 | Bored, 12-inch | 156 | 122 | 391 | 35 | Compressed air | 1,000.00 | 2,000.00 | Irrigation | †60 | |
| 802 | do | do | B-2 | 1899 | do | 156 | 122 | 407 | 35 | do | 1,000.00 | 2,000.00 | do | †60 | |
| 803 | do | do | B-2 | 1899 | do | 156 | 122 | 431 | 42 | do | 1,000.00 | 2,000.00 | do | †60 | |
| 804 | do | do | B-2 | 1900 | do | 155 | 121 | 376 | 40 | do | 1,000.00 | 2,000.00 | do | †60 | |
| 805 | do | do | B-2 | 1900 | do | 155 | 121 | 116 | | do | 1,000.00 | 2,000.00 | do | †60 | |
| 806 | do | do | B-2 | 1900 | do | 155 | 121 | 379 | 40 | do | 1,000.00 | 2,000.00 | do | †60 | |
| 807 | do | do | B-2 | 1900 | do | 155 | 121 | 376 | 42 | do | 1,000.00 | 2,000.00 | do | †60 | |
| 808 | do | do | B, C-4 | | Bored, 4-inch | 131 | 131 | 80 | 40 | Wind | | | Stock | | |
| 809 | do | do | C-3 | 1901 | Bored, 8-inch | 132 | 117 | 165 | | do | 231.00 | | do | | |
| 810 | do | do | D-4 | 1883? | do | 124 | 114 | 150 | 35 | do | | | do | | |
| 811 | do | do | D-3 | 1883 | Bored, 7-inch | 131 | 120 | 60 | 36 | do | | | Domestic | | |
| 812 | do | do | D-3, 4 | 1883 | do | 123 | 114 | 90 | 36 | do | | | Stock | | |
| 813 | do | do | D-3 | 1883 | do | 129 | | 60 | 31 | do | | | Domestic | | |
| 814 | do | do | E-3 | | do | 128 | 122 | 80 | 32 | do | | | Stock | | |
| 815 | do | do | C-3 | | do | 159 | 130 | 80 | 38 | do | | | do | | |
| 816 | D. Cunningham | do | B-2 | | do | 158 | 129 | 75 | 35 | do | 75.00 | | Domestic | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 817 | Michael Cudahy | San Antonio | B-2 | 1899 | Bored | | | 115 | 38 | Compressed air. | $250.00 | | Boilers | |
| 818 | D. Cunningham | do | B-2 | 1902 | Bored, 12-inch | 169 | 133 | 190 | 35 | do | 500.00 | | Irrigation | 50 |
| 819 | H. W. Benson | do | C-2 | 1884 | Bored, 2-inch | 156 | | | 72 | Hand | | $2.50 | Domestic | |
| 820 | A. F. Fishring | do | B-2 | 1903 | Bored, 7-inch | 175 | 130 | 89 | | do | 108.00 | | do | |
| 821 | Mr. Nutt | do | B-2 | 1897 | Bored, 11-inch | 170 | 130 | 280 | | Gas | | | Irrigation | †120 |
| 822 | G. H. Stevens | do | B-2 | 1902 | Bored, 7-inch | 177 | 132 | 85 | 33 | Wind | 90.00 | 250.00 | Domestic | |
| 823 | E. V. Baker | do | B-1 | | do | | | 58 | | | | | Not used | |
| 824 | Mrs. Baker | do | C-1 | 1902 | do | 173 | 150 | 60 | 53 | Hand | 60.00 | | Domestic | |
| 825 | G. W. Brookins | do | C-1 | 1902 | do | 177 | 147 | 60 | 73 | Wind | 60.00 | 150.00 | do | |
| 826 | Marian Dodson | do | B-1 | 1899 | do | 175 | 145? | 95 | 52 | Hand | 100.00 | | do | |
| 827 | Mr. Buchanan | do | B-1 | 1900 | Bored, 4-inch | 176 | | 120 | | Wind | | | do | |
| 828 | W. W. Shea | do | B, C-1 | | Bored, 7-inch | 182 | 133 | | | do | | | do | |
| 829 | Alfred Lemon | do | B-1 | 1894 | do | 182 | 141 | 77 | 54 | do | 75.00 | 200.00 | do | |
| 830 | J. H. Chapman | do | B-1 | 1895 | do | 178 | 128 | 115 | 41 | do | 115.00 | | do | |
| 831 | J. W. Batcheller | do | C-1 | 1883 | do | 184 | 138 | 95 | 37 | do | 100.00 | | do | |
| 832 | San Antonio school district. | do | C-1 | 1899 | do | | | 225 | 35 | Hand | | | do | |
| 833 | F. P. Walker | do | C-1 | 1878 | do | 185 | 139 | 90 | | Wind | 90.00 | | do | |
| 834 | E. J. Polkinhorn | do | C-1 | 1902 | do | 181 | 139 | 105 | 39 | do | 110.00 | 200.00 | do | |
| 835 | Mr. Russell | do | C-1 | 1880 | do | 179 | 139 | 80 | | do | | | Domestic; stock | |
| 836 | Wm. Angel | do | C-1 | 1901 | do | 180 | 140 | 74 | 39 | Hand | | | Domestic | |
| 837 | W. J. Barr | do | C-1 | 1902 | do | 183 | 143? | 108 | 45 | do | 160.00 | | do | |
| 838 | J. F. Francis | San Pedro | A-11 | | Dug, 3 by 3 foot | 50 | 41 | 14 | | Wind | | 75.00 | Stock | |
| 839 | Jesus Cruz | do | B-11 | 1903 | Bored, 10-inch | 49 | 42 | 143 | 31 | do | | | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 840 | Mr. Cheriotto | do | B-12 | 1903 | do | 33 | 26 | 160 | | Gas? | 300.00 | | Irrigation | | |
| 841 | Mr. Shurota | do | B 12 | 1883? | Bored, 6-inch | 33 | 26 | 150? | 45 | Hand | | | Domestic | | |
| 842 | M. Mindrup | do | B-11 | 1900 | Bored, 2-inch | 44 | | 101 | | do | 50.00 | | Not used | | |
| 843 | G. Delamo | do | C-11 | 1899 | Bored, 12-inch | 43 | 43 | 940 | 25 | Artesian | 200.00 | | Irrigation | | 35 |
| 844 | do | do | B 11 | 1900 | Bored, 2-inch | 43 | 33? | 94 | 37 | Wind | 50.00 | 150.00 | Domestic | | |
| 845 | R. M. Bobst | do | B-11 | 1901 | do | 41 | | 106 | 51 | Hand | 50.00 | | do | | |
| 846 | J. Malcom | do | B-11 | | Bored, 7-inch | 42 | 34 | 185 | 37 | Wind | | | do | | |
| 847 | Mrs. Carson | do | A-12 | | Driven, 2-inch | 30 | 24 | 95 | 37 | Hand | | | do | | |
| 848 | S. Todd | do | A-13 | | Bored, 7-inch | 25 | 20 | 275 | 37 | do | | | do | | |
| 849 | Mr. Bangel | do | B-13 | 1899 | Driven, 2-inch | 31 | 26 | 96 | | do | 50.00 | | do | | |
| 850 | Mrs. Chas. Guyer | do | B-13 | 1898 | do | 32 | 26 | 80 | 41 | Wind | | | Domestic; stock | | |
| 851 | Mrs. Carson | do | C-12 | 1898 | Bored, 10-inch | 32 | 27 | 140 | 35 | Hand | | | Domestic | | |
| 852 | do | do | C-12 | 1898 | do | 33 | 27 | 140 | 39 | Gas | | | Not used | | |
| 853 | Miss Y. Dominguez | do | B, C-12 | 1898 | do | 35 | 26 | 140 | 37 | do | | | do | | |
| 854 | J. F. Francis | do | C-11, 12 | 1900 | Driven, 2-inch | 35 | 26 | 80 | 38 | Wind | | | Domestic | | |
| 855 | G. Dominguez | do | B-11 | 1903 | Bored, 2-inch | 32 | 25 | 106 | 40 | Hand | | | do | | |
| 856 | J. F. Francis | do | C-11 | 1898 | Bored, 10-inch | 36 | 28 | 140 | | Gas | | | Not used | | |
| 857 | Schoolhouse | do | B-12 | 1895 | Bored, 2-inch | 32 | 24 | 90 | | Hand | | | Domestic | | |
| 858 | O. E. Eiftman | do | B-12 | 1902 | Bored, 12-inch | 33 | 25 | 535 | 37 | Gas | 1,100.00 | | Irrigation | | 120 |
| 859 | do | do | B-12 | 1895 | Bored, 10-inch | 33 | 25 | 143 | 41 | Wind | 275.00 | | Domestic | | |
| 860 | Geo. Silvera | do | B-11, 12 | 1902 | Bored, 2-inch | 32 | 25 | 106 | 47 | Hand | 53.00 | | do | | |
| 861 | O E. Eiftman | do | B-12 | 1902 | Bored, 12-inch | 31 | 24 | 150 | 39 | Gas | 275.00 | | Irrigation | | 120 |
| 862 | do | do | B-12 | 1895 | Bored, 2-inch | 31 | 24 | 100 | 40 | Hand | 50.00 | | Stock | | |
| 863 | M E. Tolle | do | C-13 | 1890 | Bored, 4-inch | 25 | | 86 | 44 | | | | Domestic | | |
| 864 | G. H. Bixby | Los Cerritos | C-13 | 1901 | Bored, 7-inch | 50 | 13 | 400 | 27 | Gas | | 150.00 | Domestic; stock | | |
| 865 | J. M. Carson | San Pedro | C-12 | 1900 | Bored, 2-inch | 28 | 19 | 137 | | do | 70.00 | | Domestic | | |
| 866 | do | do | B-13 | 1897 | do | 25 | | 140 | 37 | Wind | 70.00 | 150.00 | Stock | | |
| 867 | do | do | B-13 | 1900 | Bored, 10-inch | 25 | 18 | 225 | 35 | Gas | 500.00 | | Irrigation | | 100 |
| 868 | L. E. Torrey | do | B-13 | 1901 | Bored, 2-inch | 25 | 15? | 140 | 37 | Wind | 70.00 | 150.00 | Domestic | | |
| 869 | S. D. Wilson | do | B-13 | 1899 | do | 25 | 19 | 100 | | do | 50.00 | | do | | |
| 870 | Milton Brown | do | C-13 | 1888 | Dug, 3 by 3 foot | 22? | 16 | 18 | 73 | Hand | | | do | | |
| 871 | W. True Molton | do | C-13 | | Bored, 7-inch | 24 | 16 | 108 | 57 | do | | | do | | |
| 872 | Mr. Mayberry | do | C-13 | | do | 23 | 16 | 100 | 59 | Wind | | | do | | |
| 873 | A. J. Green | do | C-13, 14 | 1883 | do | 23 | 16 | 90 | | do | | | do | | |
| 874 | Mr. Kincaid | do | C-13 | 1883? | do | 23 | 16 | 110 | 200+ | do | | | do | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 875 | A. Allison | San Pedro | C-13 | 1888 | Dug, 3 by 3 foot | 22 | 17 | 8 | 200+ | Hand | | | Domestic | |
| 876 | Mrs. Francis MacDonald. | do | C-14 | 1885 | do | | | 11 | | do | | | do | |
| 877 | B. A. Mathewson | do | D-14 | 1902 | do | | | 9 | 200+ | do | | | do | |
| 878 | P. J. Watson | do | B-14 | 1897 | Bored, 4-inch | 25 | 20 | 340 | 49 | Wind | $300.00 | | Stock | |
| 879 | do | do | A-13 | 1900 | Bored, 2-inch | 23 | | 459 | 20 | Artesian | | | do | Small. |
| 880 | do | do | A-13 | 1894 | Bored, 7-inch | 25 | 3 | 154 | 29 | Wind | 250.00 | | Domestic; irrigation. | |
| 881 | San Pedro Lumber Co. | do | A-16 | 1903 | Dug, 3 by 3 foot | 23 | 12 | 15 | 55 | | | | Sawmill | |
| 882 | San Pedro Salt Co | do | B-16 | 1902 | Bored, 7-inch | 4 | 7 | 158 | 56 | Artesian | 200.00 | | Boiler | |
| 883 | G. H. Bixby | do | B-15 | | do | 15 | 12 | 86 | 37 | Wind | | | Stock; domestic | |
| 884 | L. Byrnes | do | B-15 | 1893 | Bored, 4-inch | 11 | 10 | 98 | 37 | Artesian, wind | | | Stock | Small. |
| 885 | John Ena | do | B-15 | 1898 | Bored, 12-inch | 11 | 13 | 784 | 32 | Artesian | | | do | Small. |
| 886 | John Scott | do | B-15 | 1880 | Bored, 7-inch | 11 | 10 | 180 | | do | 200.00 | | do | |
| 887 | John Ena | do | C-15 | 1885? | do | 15 | 14 | | 39 | do | | | do | Small. |
| 888 | Geo. Cordell | do | C-15 | 1890 | do | 11 | | 100 | 38 | Hand | 100.00 | | Domestic | |
| 889 | Geo. Loper | do | B-15 | 1901 | Bored, 4-inch | 14 | | 100 | 38 | do | 75.00 | | do | |
| 890 | Ira Roberts | do | B-14 | | Driven, 2-inch | 15 | 12 | 85 | | do | 45.00 | $2.50 | do | |
| 891 | W. Martin | do | B-14 | 1888 | Bored, 4-inch | 16 | 13 | 100 | 38 | Wind | 85.00 | | do | |
| 892 | F. W. Gilson | do | B-14 | 1888? | Bored, 7-inch | 16 | 11 | 100 | 31 | Hand | 100.00 | | do | |
| 893 | W. H. Westover | do | B-14 | 1888 | Bored, 6-inch | 15 | 11 | 100 | | Wind | | | do | |
| 894 | E. Loper | do | B-14 | 1893 | Bored, 4-inch | 17 | 12 | 100 | 37 | do | 75.00 | 135.00 | do | |
| 895 | M. Pike | do | B-14 | 1888? | Bored, 7-inch | 18 | 12 | 95 | 35 | do | 95.00 | | do | |
| 896 | Fred Maskew | do | B-14 | 1896 | Bored, 2-inch | 18 | 12 | 96 | 37 | Hand | 35.00 | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 897 | Mrs. E. M. Wiley | do | B-14 | 1897 | Bored, 4-inch | 18 | 12 | 85 | 37 | Wind | 70.00 | 150.00 | do | | |
| 898 | P. J. Watson | do | A-14 | 1885 | Dug, 4 by 4 foot | 25 | 12 | 21 | 70 | do | | | do | | |
| 899 | Mrs. Lily Watson | do | A-14 | | Bored, 7-inch | 28 | 9 | 162 | 30 | do | | | do | | |
| 900 | Mrs. Emery | do | B 14 | 1896 | Bored, 2-inch | 18 | 11 | 85 | | Hand | | | do | | |
| 901 | Mrs. Guyer | do | B-12 | 1899 | Bored, 10-inch | 31 | 24 | 149 | | Gas | 200.00 | | Irrigation | 125 | |
| 902 | G. N. Wines | do | B-13 | | Bored, 2-inch | 20 | 19? | 170 | 33 | Wind | | | Domestic | | |
| 903 | R. H. Martin | do | B, C-14 | 1892 | Bored, 6-inch | 17 | 11 | 116 | | do | 115.00 | | do | | |
| 904 | Cerritos school district | do | C-14 | 1883 | Bored, 2-inch | 17 | 11 | 90 | | Hand | 45.00 | | do | | |
| 905 | S. O. Davis | do | C-14 | 1880 | Bored, 6-inch | 17 | 12 | 120 | 62 | Wind | | | do | | |
| 906 | do | do | C-14 | 1887 | do | 14 | 9 | 110 | | | | | Not used | | |
| 907 | Mrs. Graydon | do | C-14 | 1891 | Bored, 4-inch | 14 | 9 | 100 | | Wind | | | Domestic | | |
| 908 | John Leuer | do | C-15 | 1885 | do | 13 | 12 | 92 | | Hand | | | do | | |
| 909 | E. S. Rosenberg | do | C-15 | 1895 | Bored, 6-inch | 15 | 11 | 105 | 39 | Wind | | | Domestic; irrigation. | | |
| 910 | C. A. Westgate | do | C-14 | 1885 | Bored, 7-inch | 14 | 12 | 100 | 60 | do | | | Domestic | | |
| 911 | Henry Schief | do | C-14 | 1898 | Bored, 2-inch | 13 | 11 | 94 | 60 | Hand | 35.00 | | do | | |
| 912 | Geo. Cordell | do | C-15 | 1888 | Bored, 7-inch | 13 | 12 | 125 | | Wind | | | do | | |
| 913 | Mrs. B. F. Browers | Los Cerritos | D-15 | | | 23 | 11 | 70 | 200+ | do | | | do | | |
| 914 | Frank Pit | do | C-15 | | Bored, 2-inch | 20 | | 80? | 70 | do | | | do | | |
| 915 | H. F. Mallernee | do | E-10 | 1897 | do | 53 | 51 | 317 | | | 125.00 | | Not used | | |
| 916 | Geo. H. Bixby | do | E-11 | 1898 | Bored, 10-inch | 51 | 51 | 672 | 20 | Artesian | | | Irrigation | 190 | |
| 917 | do | do | E-11 | | Bored, 2-inch | 52 | 52 | 350? | 20 | do | 300.00 | | Domestic; stock | | |
| 918 | do | do | E-11 | | Bored, 7-inch | 52 | 52 | 350 | 23 | do | | | Stock | | |
| 919 | do | do | D-11 | 1897 | Bored, 10-inch | 48 | | 500+ | 23 | do | | | do | 1 | |
| 920 | do | do | D-11 | | Bored, 7-inch | 45 | 45 | 310? | 23 | do | | | do | 2 | |
| 921 | do | do | D-11 | | do | 45 | | 350? | 25 | do | | | Irrigation | 4 | |
| 922 | do | do | D-12 | 1869 | do | 80 | 48 | 350? | 22 | Wind | | | Domestic | | |
| 923 | do | do | D-12 | 1898 | Bored, 10-inch | 105 | 50 | 500 | 22 | Gas | | | do | | |
| 924 | do | do | D-13 | | Bored, 4-inch | 100 | | 400? | 22 | Wind | | | do | | |
| 925 | R. F. De Garmo | do | D-15 | 1890? | Dug, 3 by 3 foot | 25 | 11 | 21 | 161 | do | | | do | | |
| 926 | G. W. Olsen | do | D-14 | 1903 | do | 24 | 11 | 15 | 172 | Hand | | | do | | |
| 927 | R. W. Patterson | do | D-14 | 1894 | Bored, 7-inch | 59 | 4 | 425? | 37 | Wind | 1,000.00 | | Domestic; irrigation. | | |
| 928 | A. M. Neece | do | D-14 | 1891 | do | 50 | 10 | 240 | 39 | do | 500.00 | | Domestic | | |
| 929 | J. Andrews | do | D-14 | 1890 | do | 45 | 31 | 120 | 80 | do | *503.00 | | Domestic; irrigation. | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 930 | J. B. Rain | Los Cerritos | E-14 | 1888 | Bored, 4-inch | 73 | 21 | 264 | | | | | Not used | |
| 931 | Mr. Wardlowe | do | E-14 | | Bored, 7-inch | 63 | 21 | | 36 | Wind | | | Domestic; irrigation. | |
| 932 | Z. T. Nelson | do | E-14 | | do | 100 | 9 | 155 | | do | | | do | |
| 933 | G. A. Lindsay | do | D-16 | 1897 | Bored, 4-inch | 37 | 12 | 72 | 27 | do | | | Irrigation | |
| 934 | Seaside Water Co | do | E-12 | | Bored, 14-inch | 61 | 61 | 730 | 21 | Artesian | | | Domestic | |
| 935 | do | do | E-12 | | Bored, 14, 12-inch | 61 | 61 | 700 | | do | | | | |
| 936 | do | do | E-12 | 1900 | Bored, 12-inch | 61 | 61 | 767 | | do | | | Domestic | |
| 937 | do | do | E-12 | | Bored, 10-inch | 71 | 71 | 400 | 19 | | | | Not used | |
| 938 | do | do | E-12 | | Bored, 7-inch | 61 | 61 | 400 | | | | | Irrigation | |
| 939 | do | do | E-13 | 1901 | Bored, 14-inch | 62 | 62 | 684 | 19 | Artesian | | | Domestic | †100 |
| 940 | do | do | E-13 | 1899 | Bored, 8-inch | 57 | 57 | 707 | 19 | do | | | do | |
| 941 | Geo. H. Bixby | do | E-13 | 1888 | Bored, 7-inch | 62 | 62 | 250 | 21 | do | | | Not used | |
| 942 | do | do | E-13 | 1902 | Bored, 2-inch | 62 | | 450 | 22 | do | | | Domestic | Small. |
| 943 | Seaside Water Co | do | E-13 | | do | 60 | 60 | 350 | 21 | do | | | Not used | |
| 944 | J. Ross Clark | do | E-12 | 1900 | Bored, 12-inch | 61 | 61 | 838 | 23 | do | $2,500.00 | | Irrigation | †95 |
| 945 | W. A. & J. R. Clark | do | E-12 | 1893 | Bored, 10-inch | 69 | 69 | 350 | | | | | Domestic | |
| 946 | do | do | E-12 | 1893 | Bored, 8-inch | 69 | 69 | 350 | | Artesian | | | Stock | |
| 947 | do | do | F-12 | 1901 | Bored, 4-inch | 57 | 57 | 400 | 17? | do | 280.00 | | Domestic | 12 |
| 948 | do | do | F-12 | 1901 | do | 52 | 52 | 400 | | do | 280.00 | | Stock | 17 |
| 949 | do | do | F-12 | 1901 | do | 60 | 60 | 400 | 17? | do | 280.00 | | do | 12 |
| 950 | Seaside Water Co | do | E-13 | | Bored, 2-inch | 53 | 53 | | | do | | | do | 3 |
| 951 | do | do | E-13 | | do | 53 | 53 | | | do | | | Not used | |
| 952 | G. R. Wilson | do | E-10 | 1899 | do | 58 | 58 | 420 | | do | | | Irrigation; stock | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 953 | do | do | E-10 | 1899 | do | 57 | 57 | 410 | 25 | do | 250.00 | | Domestic | | |
| 954 | W. H. McKelvey | do | F-10 | 1899 | do | 57 | 57 | 410 | 23 | do | | | Stock | †3 |
| 955 | Geo. H. Bixby | do | F-10 | 1902 | do | 57 | 57 | 400? | 22 | do | | | Not used | |
| 956 | D. B. Gemmill | do | F-10 | 1900 | Bored, 7-inch | 56 | 54 | 100? | 35 | Gas | | | Irrigation | |
| 957 | do | do | F-10 | 1900 | Bored, 2-inch | 56 | 54? | 100 | 25 | Hand | 40.00 | | Domestic | |
| 958 | G. F. Sparks | do | G-11 | 1876? | Bored, 4-inch | 52 | 52 | 400? | 25 | Artesian | | | Domestic; stock | 5 |
| 959 | J. R. Clark | do | H-11 | 1902 | do | 51 | 51 | 373 | | do | 225.00 | | Irrigation | 15 |
| 960 | do | do | H-11 | 1897 | Bored, 2-inch | 51 | 51 | 400 | 23 | do | 200.00 | | Domestic | |
| 961 | J. Ross Clark | do | H-11 | 1902 | Hydraulic, 4-inch | 52 | 52 | 403 | 23 | do | | | Irrigation | 15 |
| 962 | do | do | G-11 | 1902 | Bored, 4-inch | 52 | 52 | 420 | | do | 225.00 | | do | 27 |
| 963 | do | do | H-11 | 1902 | do | 51 | 51 | 398 | 23 | do | 225.00 | | do | |
| 964 | do | do | H-11 | 1900 | Bored, 10-inch | 47 | 47 | 700 | 22 | do | 1,800.00 | | do | 39 |
| 965 | do | do | I-1 | 1891 | Bored, 2-inch | 43 | 43 | 400? | 23 | do | | | Domestic | Small. |
| 966 | do | do | I-12 | 1895 | do | 35 | 35 | 130 | 30 | do | | | do | Small. |
| 967 | do | do | I-12 | 1890? | do | 33 | 33 | 140 | 28 | do | 60.00 | | do | |
| 968 | C. W. Coseboon | do | E-14 | 1885 | Bored, 7-inch | 150 | 98 | 180 | 25 | Wind | | $70.00 | do | |
| 969 | Citizens' Water, Light and Power Co. | Los Alamitos | F-14 | 1903 | Bored, 12-inch | 43 | 43 | 420 | 19 | Artesian | 1,000 00 | | do | 33 |
| 970 | do | do | F-14 | 1903 | do | 41 | 41 | 460 | | do | 1,200.00 | | Not used | †150 |
| 971 | do | do | F-14 | | do | 46 | 46 | 713 | | do | | | do | |
| 972 | Geo. H. Bixby | do | F-14 | 1883 | Bored, 7-inch | 46 | 46 | 450? | 19 | do | | | Stock | †5 |
| 973 | Bixby Land Co | do | F-14 | 1901 | Bored, 12-inch | 45 | 45 | 619 | | do | | | Irrigation | 61 |
| 974 | do | do | F-14 | 1902 | do | 46 | 46 | 400? | 20 | do | | | Domestic | |
| 975 | do | do | F-13 | 1902 | Bored 9½-inch | 36 | 36 | 427 | 20 | do | | | Irrigation | 160 |
| 976 | J. Ross Clark | Los Cerritos | G-12, 13 | 1890 | Bored, 4-inch | 28 | 28 | 412? | 19 | Artesian, hand | 280.00 | | Domestic | Small. |
| 977 | do | do | G-12 | 1902 | Bored, 2-inch | 38 | 38 | 74 | 21 | Artesian | 35.00 | | do | |
| 978 | do | do | G-12 | 1897 | Bored, 7-inch | 38 | 38 | 400? | 21 | do | | | do | |
| 979 | G. R. Clark | do | H-12 | 1898 | Bored, 2-inch | | | 325 | 19 | do | 150.00 | | do | |
| 980 | do | do | H-12 | 1901 | Bored, 4-inch | | | 350 | 19 | do | 250.00 | | Irrigation | |
| 981 | do | do | H-12 | 1901 | do | 34 | 34 | 350 | 19 | do | 250.00 | | do | 5 |
| 982 | do | do | H-12 | 1901 | do | 34 | 34 | 350 | 19 | do | 250.00 | | do | 8 |
| 983 | do | do | H-12 | 1901 | do | 34 | 34 | 350 | 19 | do | 250.00 | | do | 8 |
| 984 | do | do | H-13 | 1903 | do | 25 | 25 | 336 | 21 | do | 252.00 | | Domestic; irrigation. | 20 |
| 985 | do | do | H-13 | 1901 | do | 25 | 25 | 311 | | | 224.20 | | Irrigation | |
| 986 | do | do | H-13 | 1902 | do | 23 | 23 | 320 | | Artesian | 240.00 | | do | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 987 | Bixby Land Co. | Los Alamitos | H-14 | 1895 | Bored, 2-inch | 23 | 23 | 260 | 19 | Artesian | $150.00 | | Domestic | |
| 988 | do | do | H-14 | 1899 | Hydraulic, 4-inch | 23 | 23 | 268 | 19 | do | 200.00 | | Irrigation | 39 |
| 989 | do | do | H-14 | 1900 | do | 23 | 23 | 268 | 19 | do | 200.00 | | do | 35 |
| 990 | do | do | H-14 | | Bored, 2-inch | 21 | 21 | 260 | | do | | | Not used | |
| 991 | Fred Bixby | do | H-14 | 1903 | Bored, 12-inch | 21 | 21 | 848 | 17 | do | 2,500.00 | | Irrigation | 306 |
| 992 | do | do | G-14 | 1901 | Bored, 8-inch | 27 | 27 | 189 | 19 | do | | | Domestic | 14 |
| 993 | Alamitos Beach Water Co. | do | F-14 | 1901 | Bored, 12-inch | 38 | 38 | 725 | 19 | do | 2,000.00 | | Domestic; irrigation. | 137 |
| 994 | do | do | F-14 | 1902 | do | 38 | 38 | 270 | 19 | do | | | Irrigation; domestic. | 61 |
| 995 | do | do | F-14 | 1903? | do | 40 | 40 | | | do | | | | |
| 996 | Mrs. M. Nelson | Los Cerritos | D-16 | 1892? | Bored, 4-inch | 39 | 39 | 70 | 96 | Wind | | | Domestic | |
| 997 | John Shrodes | do | D-16 | 1898 | do | 30 | 30 | 50? | 200+ | do | | | Stock | |
| 998 | People's Ice Plant | do | D-16 | 1903 | Bored, 3-inch | 42 | 12 | 70 | 200+ | | 35.00 | | Factory | |
| 999 | M. E. Swingel | Los Alamitos | E-15 | 1900 | Bored, 8-inch | 41 | 15 | 60 | | Wind | | | Not used | |
| 1000 | W. A. Peck | do | E-16 | 1897 | Bored, 7-inch | 50 | 5 | 70 | | do | | | Irrigation | |
| 1001 | D. S. Shaw | do | E-16 | 1898 | Bored, 8-inch | 48 | 15 | 920 | 200+ | do | 3,500.00 | | do | |
| 1002 | Alamitos Beach Water Co. | do | G-16 | 1887 | do | 45 | 45 | 360 | 21 | | | | Not used | |
| 1003 | do | do | D-16 | 1895 | Hydraulic, 2-inch | 45 | 45 | 114 | 19 | | 50.00 | | do | |
| 1004 | Fred H. Bixby | do | H-16 | 1893 | Bored, 2-inch | 45 | 45 | 250 | 29 | Artesian | 150.00 | | Domestic | Small. |
| 1005 | do | do | H-16 | 1893 | do | 45 | 45 | 250 | 19 | do | 150.00 | | Irrigation | 2 |
| 1006 | do | do | I-16 | 1897 | do | 12 | 12 | 110 | 23 | do | 60.00 | | Domestic; stock. | Small. |
| 1007 | do | do | I-14 | 1902 | Bored, 4-inch | 13 | 13 | 375 | 31 | do | 350.00 | | Irrigation | 31 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1008 | do | do | I-14 | 1902 | do | 14 | 14 | 375 | 25 | do | 350.00 | | do | † 14 |
| 1009 | do | do | K-16 | 1902 | do | 18 | 18 | 300 | 26 | do | 300.00 | | do | 37 |
| 1010 | do | do | K, L-15 | 1902 | do | 20 | 20 | 350 | 25 | do | 325.00 | | do | 32 |
| 1011 | do | do | M 15 | 1902 | do | 25 | 25 | 415 | | do | 375.00 | | do | 18 |
| 1012 | do | do | L-15 | 1902 | do | 22 | 22 | 350 | 24 | do | 325.00 | | do | 28 |
| 1013 | do | do | J-15 | 1895 | Hydraulic, 2-inch. | 12 | 12 | 250 | 26 | do | 150.00 | | Stock | Small. |
| 1014 | do | do | K-15 | 1895 | do | 20 | 20 | 250 | | do | 150.00 | | do | 2 |
| 1015 | do | do | M-15 | 1897 | do | 28 | 28 | 250 | | do | 150.00 | | do | Small. |
| 1016 | do | do | L-16 | | Bored, 7-inch | 21 | 21 | 300 | 23 | do | | | do | Small |
| 1017 | Bixby Land Co | do | I-14 | 1900 | Bored, 4-inch | 15 | 15 | 300 | 25 | do | 225.00 | | Irrigation; domestic. | |
| 1018 | Wm. Carlson | do | I-14 | 1900 | Hydraulic, 3-inch. | 16 | 16 | 300+ | 21 | do | 140.00 | | Domestic; irrigation. | 14 |
| 1019 | Bixby Land Co | do | I-14 | 1902 | Bored, 2-inch | 15 | 15 | 295 | 21 | do | 95.00 | | Domestic | |
| 1020 | do | do | I-14 | 1902 | Hydraulic, 2-inch. | 14 | 14 | 309 | 23 | do | 115.00 | | Domestic; irrigation. | 11 |
| 1021 | do | do | H-14 | 1902 | Bored, 2-inch | 15 | 15 | 300? | 23 | do | 136.00 | | Domestic | 11 |
| 1022 | do | do | I-14 | 1878? | do | 16 | 16 | 300+ | 25 | do | | | do | |
| 1023 | do | do | I-13 | 1900 | Bored, 4-inch | 19 | 19 | 350 | 21 | do | | | Domestic; irrigation. | 14 |
| 1024 | do | do | I-13 | 1902 | Hydraulic, 2-inch. | 20 | 20 | 303 | 22 | do | 126.00 | | Domestic | 10 |
| 1025 | do | do | H-13 | 1902 | Bored, 12-inch | 21 | 21 | 882 | | do | 4,000.00 | | Irrigation | †95 |
| 1026 | do | do | I-12 | 1902 | do | 25 | 25 | 740 | 22 | do | 3,500.00 | | do | 150 |
| 1027 | J. H. Brown | do | H-13 | 1900 | Hydraulic, 4-inch. | 21 | 21 | 280 | 22 | do | 140.00 | | Domestic | 20 |
| 1028 | Bixby Land Co | do | H-14 | 1901 | Hydraulic, 2-inch. | 16 | 16 | 300 | 21 | do | 140.00 | | do | |
| 1029 | do | do | H-14 | 1891 | Bored, 4-inch | 21 | 21 | 268 | 21 | do | 150.00 | | do | 21 |
| 1030 | J. Ross Clark | do | H-12 | 1890 | Bored, 7-inch | | | 500 | 25 | do | | | Irrigation | 42 |
| 1031 | do | do | H-12 | 1900 | Hydraulic, 2-inch. | 32 | 32 | 312 | 23 | do | 150.00 | | Domestic | |
| 1032 | do | do | G-11 | 1902 | Bored, 4-inch | 49 | 49 | 420 | 25 | do | 285.00 | | Irrigation | |
| 1033 | do | do | H-11 | | Bored, 2-inch | 48 | 48 | 400? | 25 | do | | | Domestic | Small. |
| 1034 | Bixby Land Co | Los Cerritos | I-13 | 1895 | Hydraulic, 2-inch. | 23 | 23 | 300? | 21 | do | 150.00 | | do | |
| 1035 | I. W. Hellman | Los Alamitos | J-17 | 1898 | Bored, 2-inch | 30 | 30 | 200+ | 21 | do | | | Domestic; stock. | Small. |
| 1036 | do | do | J-17 | 1898 | do | 28 | 24 | 145 | 25 | Hand | 7.00 | | Domestic | |
| 1037 | do | do | J-17 | 1896 | do | 23 | 23 | 413 | | Artesian | | | Irrigation; domestic. | 5 |
| 1038 | do | do | K-17 | | do | 11 | 11 | | | do | | | Stock | |
| 1039 | do | do | K-17 | 1890? | Bored, 4-inch | 12 | 12 | 250? | 26 | do | | | do | 8 |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1040 | I. W. Hellman | Los Alamitos | K-17 | 1897? | Hydraulic, 4-inch. | 12 | 12 | 150 | | Artesian | | | Stock | †8 |
| 1041 | do | do | L-17 | 1895 | Bored, 7-inch | 16 | 16 | 151 | | do | | | do | 19 |
| 1042 | do | do | L-16 | 1902 | Bored, 2-inch | 17 | 17 | 280 | | do | $140.00 | | Irrigation | 8 |
| 1043 | do | do | K-16 | 1899 | Bored, 4-inch | 14 | 14 | 120 | 25 | do | 40.00 | | do | 25 |
| 1044 | do | do | K-17 | 1899 | Bored, 2-inch | 19 | 19 | 120 | | do | | | Not used | |
| 1045 | do | do | L-16 | 1900 | do | 14 | 14 | 180 | | do | 65.00 | | Irrigation | 7 |
| 1046 | do | do | K-16 | 1899 | do | 15 | 15 | 185 | 25 | do | 65.00 | | Domestic | |
| 1047 | do | do | K-16 | 1900 | Bored, 4-inch | 15 | 15 | 125 | 25 | | | | Irrigation | 1 |
| 1048 | do | do | K-16 | 1901 | Bored, 2-inch | 16 | 16 | 265 | 26 | Artesian | 75.00 | | do | 2 |
| 1049 | do | do | K-16 | 1897 | do | | | 190 | 26 | do | | | do | 3 |
| 1050 | do | do | L-16 | 1901 | do | 16 | 16 | 130 | 25 | do | 75.00 | | do | 4 |
| 1051 | do | do | K-16 | 1900 | Bored, 4-inch | 17 | 17 | 250 | 25 | do | 180.00 | | do | 1 |
| 1052 | do | do | M-17 | 1901 | do | 23 | 23 | 340 | | do | | | Irrigation; domestic. | 22 |
| 1053 | David Rodgers | do | M-17 | 1901 | do | 19 | 19 | 269 | 29 | do | 162.00 | | Stock | |
| 1054 | do | Las Bolsas | M-17 | 1901 | Bored, 3-inch | 19 | 19 | 274 | 28 | do | 150.00 | | do | 8 |
| 1055 | do | do | M-17 | 1899 | Bored, 2-inch | 19 | 19 | 285 | 27 | do | 140.00 | | Domestic; stock. | 5 |
| 1056 | J. R. Robinson | do | M-17 | 1902 | Bored, 4-inch | 21 | 21 | 270 | 26 | do | 175.00 | | Irrigation | 8 |
| 1057 | David Rodgers | do | M-17 | 1897 | Bored, 2-inch | 23 | 23 | 330 | 28 | do | | | Domestic | |
| 1058 | J. R. Robinson | do | M-17 | 1893 | do | 22 | 22 | 250? | 26 | do | | | Irrigation | 4 |
| 1059 | do | do | M-17 | 1893 | do | 22 | 22 | 250? | | do | | | do | 4 |
| 1060 | D. K. Schaffer | do | M-17 | 1900 | do | 23 | 23 | 250 | 28 | do | 125.00 | | Irrigation; domestic. | 4 |
| 1061 | do | do | M-17 | 1900 | do | 22 | 22 | 250? | 22 | do | 125.00 | | Irrigation | 4 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1062 | .....do..... | .....do..... | M 17.... | 1900 | .....do..... | 23 | 23 | 250? | 25 | .....do..... | 125.00 | ..... | .....do..... | 4 |
| 1063 | T. Willotts..... | .....do..... | M 17.... | 1897 | .....do..... | 23 | 23 | 100 | 26 | .....do..... | 100.00 | ..... | Domestic..... | 5 |
| 1064 | .....do..... | .....do..... | M 17.... | 1897 | .....do..... | 23 | 23 | 195 | 24 | .....do..... | 100.00 | ..... | Irrigation..... | 8 |
| 1065 | Geo. Berenstein..... | .....do..... | M-17.... | 1899 | .....do..... | 21 | 21 | 190 | 28 | .....do..... | 100.00 | ..... | Domestic..... | 2 |
| 1066 | .....do..... | .....do..... | M-17.... | 1899 | .....do..... | 22 | 22 | 190 | 27 | .....do..... | ..... | ..... | Irrigation..... | 3 |
| 1067 | .....do..... | .....do..... | M-17.... | 1893 | Bored, 7-inch..... | 22 | 22 | 90 | 27 | .....do..... | 100.00 | ..... | Stock..... | Small. |
| 1068 | .....do..... | .....do..... | M-17.... | 1890 | .....do..... | 23 | 23 | 150? | 26 | .....do..... | ..... | ..... | .....do..... | 7 |
| 1069 | Mr. Sharp..... | .....do..... | M-17.... | 1892? | Bored, 2-inch..... | 23 | 23 | 200? | 27 | .....do..... | ..... | ..... | Domestic; irrigation. | 3 |
| 1070 | H. C. Woodward & Co | .....do..... | M-17.... | 1886 | Bored, 7-inch..... | 23 | 23 | 333 | 29 | .....do..... | ..... | ..... | Domestic..... | †2 |
| 1071 | Mr. E. B. Finley..... | .....do..... | N-17.... | 1888 | .....do..... | 26 | 26 | 150 | 27 | .....do..... | 150.00 | ..... | .....do..... | Small. |
| 1072 | .....do..... | .....do..... | N-17.... | 1898 | Bored, 2-inch..... | 25 | 25 | 300 | 26 | .....do..... | 90.00 | ..... | Irrigation..... | 6 |
| 1073 | O. J. Buck..... | .....do..... | N-17.... | 1878 | Bored, 7-inch..... | 25 | 25 | 80 | 25 | .....do..... | 120.00 | ..... | Domestic..... | 4 |
| 1074 | J. H. Edwards..... | .....do..... | N-17.... | 1898 | Bored, 2-inch..... | 27 | 27 | 380 | 26 | .....do..... | ..... | ..... | .....do..... | 4 |
| 1075 | .....do..... | .....do..... | N-17.... | 1880? | Bored, 7-inch..... | 27 | 27 | 370? | 26 | .....do..... | ..... | ..... | Not used..... | ..... |
| 1076 | .....do..... | .....do..... | N-17.... | 1899 | Bored, 3-inch..... | 27 | 27 | 360 | 26 | .....do..... | ..... | ..... | Irrigation..... | 11 |
| 1077 | .....do..... | .....do..... | N-17.... | 1898 | Bored, 2-inch..... | 28 | 28 | 360 | 27 | .....do..... | ..... | ..... | .....do..... | ..... |
| 1078 | .....do..... | .....do..... | N-17.... | 1895 | Bored, 7-inch..... | 28 | 28 | 370 | 26 | .....do..... | 530.00 | ..... | .....do..... | 29 |
| 1079 | .....do..... | .....do..... | N-17.... | 1880? | .....do..... | 28 | 28 | ..... | .... | .....do..... | ..... | ..... | Not used..... | ..... |
| 1080 | W. G. Alford..... | .....do..... | N-17.... | 1880 | .....do..... | 27 | 27 | 300 | 28 | .....do..... | ..... | ..... | Domestic..... | †1 |
| 1081 | Sampson Edwards.... | .....do..... | N-17.... | 1897 | Bored, 2-inch..... | 27 | 27 | 300? | 28 | .....do..... | ..... | ..... | Not used..... | ..... |
| 1082 | Mrs. Clark..... | .....do..... | N-17.... | 1888 | Bored, 7-inch..... | 29 | 29 | ..... | 33 | .....do..... | ..... | ..... | Domestic..... | †1 |
| 1083 | Miss Beckworth ..... | .....do..... | N-17.... | 1888? | Bored, 2-inch..... | 89 | 89 | 100? | 29 | .....do..... | ..... | ..... | .....do..... | Small. |
| 1084 | F. Wright..... | .....do..... | N-17.... | 1901 | Bored, 6-inch..... | 31 | 31 | 100 | 34 | .....do..... | ..... | ..... | Domestic; irrigation. | 2 |
| 1085 | L. Hosking..... | .....do..... | N-17.... | 1883? | Bored, 4-inch..... | 32 | 32 | 100 | 33 | .....do..... | ..... | ..... | Domestic..... | 17 |
| 1086 | Mrs. Stewart..... | .....do..... | N-17.... | 1890? | Bored, 2-inch..... | 31 | 31 | 100? | 34 | .....do..... | ..... | ..... | .....do..... | Small. |
| 1087 | J. Caldwell..... | .....do..... | N-17.... | 1899 | .....do..... | 33 | 33 | 90 | 32 | .....do..... | ..... | ..... | .....do..... | ..... |
| 1088 | Mrs Harper..... | .....do..... | N 17..... | ..... | Bored, 3-inch..... | 31 | 31 | 100? | 27 | .....do..... | ..... | ..... | .....do..... | ..... |
| 1089 | Robert McClintock... | .....do..... | N-17.... | 1899 | Bored, 2-inch..... | 31 | 31 | ..... | 31 | .....do..... | ..... | ..... | Domestic; stock. | †1 |
| 1090 | E. E. Buck..... | .....do..... | N-17.... | 1900 | .....do..... | 31 | 31 | 100 | 29 | .....do..... | ..... | ..... | Domestic..... | ..... |
| 1091 | J. F. Patterson..... | .....do..... | N-17.... | 1894 | .....do..... | 33 | 33 | 111 | 27 | .....do..... | 42.00 | ..... | .....do..... | 4 |
| 1092 | Presbyterian parsonage. | .....do..... | N-17.... | 1902 | .....do..... | 33 | 33 | 110 | 27 | .....do..... | 50.00 | ..... | .....do..... | 6 |
| 1093 | H. Flowers..... | .....do..... | N-17.... | 1890? | Bored, 4-inch..... | 33 | 33 | 85 | 31 | .....do..... | ..... | ..... | .....do..... | ..... |
| 1094 | F. F. Skelley..... | .....do..... | N-17.... | 1895 | Bored, 2-inch..... | 33 | 33 | 142 | 29 | .....do..... | 70.00 | ..... | .....do..... | ..... |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1095 | F. F. Skelley | Las Bolsas | N-17 | 1903 | Bored, 2-inch | 33 | 33 | 112 | 28 | Artesian | $60.00 | | Domestic; irrigation. | |
| 1096 | W. E. Lossing | do | N-17 | 1880 | Driven, 2-inch | 33 | 33 | 75 | 32 | do | | | Domestic | |
| 1097 | do | do | N-17 | 1892 | Bored, 2-inch | 31 | 31 | 80 | 33 | do | 60.00 | | do | |
| 1098 | P. E. Niles | do | N-17 | 1902 | do | 32 | 32 | 335 | 24 | Wind, artesian | 140.00 | | do | |
| 1099 | R. T. Harris | do | N-17 | 1883 | Bored, 4-inch | 32 | 32 | 165 | 26 | Artesian | | | do | |
| 1100 | C. W. Baker | do | N-17 | 1895 | Bored, 2-inch | 32 | 32 | 80 | 32 | do | 21.00 | | do | |
| 1101 | John Reed | do | N-17 | 1899 | do | 31 | 31 | 110 | 26 | do | | | do | |
| 1102 | Methodist Episcopal parsonage. | do | N-17 | 1902 | do | 31 | 31 | 70 | | Artesian, hand | 60.00 | | do | |
| 1103 | Wm James | do | N-17 | 1901 | do | 31 | 31 | | 27 | Artesian | | | Irrigation | Small. |
| 1104 | Mr. Kiefhaber | do | N-17 | 1891 | Bored, 7-inch | 31 | 31 | 375 | 27 | do | 500.00 | | Domestic; irrigation. | 9 |
| 1105 | Westminster Cheese and Butter Co. | do | N-17 | 1895 | Bored, 2-inch | 30 | 30 | 80 | | do | 40.00 | | Not used | |
| 1106 | J. R. Davis | do | N-17 | 1902 | Bored, 3-inch | 30 | 30 | 366 | 29 | do | 180.00 | | Irrigation | 9 |
| 1107 | J. B. Lowsing | do | N-17 | 1897 | Bored, 2-inch | 29 | 29 | 366 | 28 | do | 150.00 | | Domestic | |
| 1108 | C. W. Baker | do | N-17 | 1897 | do | 36 | 36 | 187 | | do | 60.00 | | do | |
| 1109 | C. C. Violett | do | N-17 | 1899 | do | 35 | 35 | 125 | 31 | do | | | do | |
| 1110 | C. E. Hammond | do | N-17 | 1899 | do | 34 | 34 | 106 | 28 | do | 50.00 | | do | |
| 1111 | R. Ward | do | N-17 | 1897 | do | 30 | 30 | 80 | 33 | do | 35.00 | | Domestic; irrigation. | †4 |
| 1112 | Wm. Harvey | do | N-17 | 1899 | do | 28 | 28 | 395 | 29 | do | 60.00 | | do | 2 |
| 1113 | do | do | N-17 | 1874? | Bored, 7-inch | 28 | 28 | 96 | 29 | do | | | Stock | Small. |
| 1114 | do | do | N-17 | 1875 | do | 28 | 28 | 96 | 29 | do | | | Irrigation | 1 |
| 1115 | Sam Waters | do | N-17 | 1894 | Bored, 3-inch | 30 | 30 | 80 | 28 | do | 30.00 | | do | Small. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1116 | .....do | .....do | N-17 | 1873 | Bored, 4-inch | 30 | 30 | 83 | 28 | .....do | 50.00 | | Domestic; irrigation | Small |
| 1117 | J. R. Cavanah | .....do | N-17 | 1878 | Bored, 7-inch | 29 | 29 | 100+ | 28 | | | | Not used | |
| 1118 | .....do | .....do | N-17 | 1889 | Bored 4-inch | 29 | 29 | 100+ | 28 | Hand, artesian | | | Domestic | Small. |
| 1119 | .....do | .....do | N-17 | 1898 | Bored, 2-inch | 31 | 31 | 325 | 28 | .....do | | | Irrigation; domestic. | Small. |
| 1120 | .....do | .....do | N-17 | 1899 | Bored, 4-inch | 29 | 29 | 325 | 28 | .....do | | | Irrigation | 5 |
| 1121 | R. Naukervis | .....do | N-17 | 1900 | Bored, 2-inch | 27 | 27 | | 24 | Artesian | 30.00 | | Domestic; irrigation. | |
| 1122 | John White | .....do | M-17 | 1883? | Bored, 7-inch | 29 | 29 | | 25 | .....do | | | Domestic | Small. |
| 1123 | R. Naukervis | .....do | M-17 | 1888 | .....do | 27 | 27 | 250 | | .....do | 200.00 | | .....do | Small. |
| 1124 | Wm. Yeo | .....do | N-17 | 1895 | Bored 2-inch | 31 | 31 | 80 | | .....do | 35.00 | | .....do | Small. |
| 1125 | .....do | .....do | N-17 | 1898 | Bored 3-inch | 33 | 33 | 400 | 29 | .....do | 150.00 | | Stock | 2 |
| 1126 | Geo. Phillips | .....do | N-16 | | Bored, 7-inch | 38 | 38 | 250 | 32 | .....do | | | Not used | |
| 1127 | .....do | .....do | N-16 | 1891 | Bored, 4-inch | 42 | 24 | 250 | 32 | .....do | | | Domestic; irrigation. | 5 |
| 1128 | .....do | .....do | N-16 | 1888? | Bored, 7-inch | 41 | 41 | 250 | 26 | .....do | | | Stock | Small. |
| 1129 | C. A. Phelps | .....do | N-16 | | Bored, 2-inch | 45 | 45 | | 28 | .....do | | | Domestic | |
| 1130 | G. K. Lien | .....do | N-16 | 1901 | Bored, 4-inch | 38 | 38 | 275 | 27 | .....do | 300.00 | | Domestic; irrigation. | |
| 1131 | .....do | .....do | N-16 | | Bored 8-inch | 38 | 38 | 200+ | 27 | .....do | | | Stock | |
| 1132 | C. W. Dickey | .....do | N-16 | 1883 | Bored, 7-inch | 41 | 41 | 230 | 27 | .....do | | | Domestic; stock. | Small. |
| 1133 | .....do | .....do | N-16 | 1897 | Bored 3-inch | 41 | 41 | 211 | 27 | .....do | 75.00 | | Irrigation | 5 |
| 1134 | .....do | .....do | N-16 | 1897 | Bored, 7-inch | 41 | 41 | 230 | 27 | .....do | 288.00 | | .....do | Small. |
| 1135 | Geo. Abbott | .....do | N-16 | 1890? | .....do | 40 | 40 | 78 | 25 | Wind, artesian | | | Not used | |
| 1136 | Mrs. Lucy Roberts | .....do | N-16 | | Bored, 2-inch | 41 | 41 | 100+ | 22 | Artesian | | | Domestic; irrigation. | Small. |
| 1137 | E. D. Barton | .....do | N-16 | 1880? | Bored, 7-inch | 42 | 42 | 230 | 26 | .....do | 500.00 | | Domestic | |
| 1138 | .....do | Los Alamitos | N-16 | 1889 | .....do | 43 | 43 | 230 | 26 | .....do | 400.00 | | Stock | Small. |
| 1139 | I. W. Hellman | .....do | N-15 | 1888? | .....do | 39 | 39 | | 26 | .....do | | | .....do | Small. |
| 1140 | G. D. Neil | Los Coyotes | N-14 | 1896 | Bored, 2-inch | 48 | 48 | 150 | 24 | .....do | 60.00 | | Domestic; irrigation | Small. |
| 1141 | .....do | .....do | N-14 | 1899 | .....do | 53 | 53 | 150 | 29 | .....do | 70.00 | | Irrigation; stock. | Small. |
| 1142 | J. Klemm | .....do | N-14 | 1897 | .....do | 58 | 58 | 287 | 26 | Artesian, wind | 150.00 | | Domestic | |
| 1143 | John Wolff | .....do | N-13 | 1898 | .....do | 58 | | 149 | 27 | Hand | 70.00 | | .....do | |
| 1144 | F. Jabs | .....do | N-13 | 1898 | .....do | 58 | 58 | 165 | 28 | Artesian | | | Stock; domestic | Small. |
| 1145 | A. Dargetz | .....do | N-13 | 1898 | .....do | 58 | 58 | 181 | 27 | .....do | 60.00 | | Domestic | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1146 | J. Jabs | Los Coyotes | N-13 | 1896 | Bored, 2-inch | 60 | 60 | 300+ | 26 | Artesian | $105.00 | | Domestic; stock. | Small. |
| 1147 | W. J. Cole | do | N-13 | 1892 | Bored, 7-inch | 60 | 58 | 189 | 26 | Wind; gas | 235.00 | | Domestic; irrigation. | †30 |
| 1148 | do | do | N-13 | 1901 | do | 53 | 51 | 189 | 27 | Wind | 190.00 | | Stock; irrigation. | |
| 1149 | J. Seaman | do | N-13 | 1902 | Bored, 4-inch | 59 | 52 | 106 | 27 | do | 90.00 | | Domestic | |
| 1150 | H. Hansen | do | N-12 | 1900 | Bored, 6-inch | 59 | 54 | 156 | 26 | Gas | 140.00 | $318.00 | Domestic; irrigation. | †18 |
| 1151 | do | do | N-12 | 1896 | Bored, 2-inch | 59 | | 274 | 26 | do | 97.00 | | do | |
| 1152 | S. Huff | do | N-12 | 1901 | Bored, 7-inch | 62 | 56 | 170 | 25 | Wind | | 125.00 | do | |
| 1153 | do | do | N-12 | 1890 | Bored, 2-inch | 62 | | 170 | 25 | Hand | | | Domestic | |
| 1154 | Mr. Kruger | do | N-12 | 1900? | Bored, 1¼-inch | 63 | | | 31 | do | | | do | |
| 1155 | Bixby Land Co | Los Alamitos | M-14 | 1902 | Bored 4-inch | 38 | 38 | 474 | 27 | Artesian | 385.20 | | Irrigation | 22 |
| 1156 | do | do | M-14 | 1901 | do | 36 | 36 | 380 | 24 | do | 220.00 | | do | 27 |
| 1157 | do | do | M-14 | 1901 | do | 36 | 36 | 365 | 25 | do | 220.00 | | do | 27 |
| 1158 | do | do | M-14 | 1901 | do | 36 | 36 | 359 | 25 | do | 225.00 | | do | 24 |
| 1159 | do | do | M-14 | 1901 | do | 33 | 33 | 396 | 28 | do | 250.00 | | do | 30 |
| 1160 | do | do | M-14 | 1901 | do | 33 | 33 | 368 | 26 | do | 225.00 | | do | 26 |
| 1161 | do | do | M-14 | 1901 | do | 33 | 33 | 358 | 25 | do | 225.00 | | do | 24 |
| 1162 | do | do | M-14 | 1901 | do | 32 | 32 | 362 | 25 | do | 225.00 | | do | 21 |
| 1163 | do | do | M-14 | 1901 | do | 32 | 32 | 358 | 25 | do | 225.00 | | do | 17 |
| 1164 | do | do | L-15 | 1902 | do | 24 | 24 | 466 | 28 | do | 400.00 | | do | 38 |
| 1165 | do | do | K-14 | 1901 | do | 23 | 23 | 418 | 26 | do | 350.00 | | do | 31 |
| 1166 | do | do | K-14 | 1902 | do | 18 | 18 | 316 | 28 | do | 200.00 | | Domestic | 21 |
| 1167 | do | do | K-14 | 1900 | Bored, 2-inch | 19 | 19 | 358 | 28 | do | 150.00 | | do | 6 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1168 | .....do..... | .....do..... | K-14.... | 1897 | .....do..... | 19 | 19 | 300 | .... | .....do..... | ..... | ..... | .....do..... | 6 |
| 1169 | .....do..... | .....do..... | J-14.... | 1901 | .....do..... | 15 | 15 | 350 | 27 | ..... | ..... | ..... | .....do..... | 9 |
| 1170 | .....do..... | .....do..... | M-14.... | 1888 | .....do..... | 37 | 37 | 150 | 27 | Artesian ..... | ..... | ..... | .....do..... | Small. |
| 1171 | Mr. Stump..... | Los Coyotes..... | M-14.... | 1900 | Bored 4-inch..... | 42 | 42 | 375? | 26 | .....do..... | ..... | ..... | Irrigation..... | 26 |
| 1172 | Bixby Land Co..... | Los Alamitos..... | M-14.... | 1890? | Bored, 2-inch.... | 36 | 36 | ..... | 27 | .....do..... | ..... | ..... | Domestic..... | ..... |
| 1173 | Fred Bixby..... | .....do..... | J-14, 15. | 1899 | .....do..... | 14 | 14 | 117 | .... | .....do..... | ..... | ..... | Irrigation; domestic. | ..... |
| 1174 | Southern Pacific Co... | .....do..... | K-14.... | 1896 | Bored, 8-inch..... | 20 | 20 | ..... | 28 | Wind..... | ..... | ..... | Engines..... | ..... |
| 1175 | Los Alamitos Sugar Co. | .....do..... | K-14.... | 1896 | Bored, 2-inch..... | 20 | 20 | 708 | .... | ..... | 250.00 | ..... | Not used..... | ..... |
| 1176 | .....do..... | .....do..... | J-14.... | 1897 | Bored, 10-inch.... | 20 | 20 | 560 | 31 | Artesian..... | ..... | ..... | Irrigation; factory. | ..... |
| 1177 | .....do..... | .....do..... | J-14.... | 1897 | .....do..... | 20 | 20 | 473 | .... | Artesian; compressed air. | ..... | ..... | Factory..... | †20 |
| 1178 | .....do..... | .....do..... | J-14.... | 1897 | .....do..... | 19 | 19 | 439 | 29 | .....do..... | ..... | ..... | .....do..... | †15 |
| 1179 | .....do..... | .....do..... | K-14.... | 1897 | .....do..... | 19 | 19 | 443 | 29 | Artesian..... | ..... | ..... | Not used..... | ..... |
| 1180 | .....do..... | .....do..... | K-14.... | 1897 | .....do..... | 19 | 19 | 469 | 30 | Artesian; compressed air. | ..... | ..... | Factory..... | †15 |
| 1181 | .....do..... | .....do..... | K-13, 14. | 1901 | Bored, 12-inch.... | 19 | 19 | 560 | 28 | Artesian..... | ..... | ..... | .....do..... | †15 |
| 1182 | .....do..... | .....do..... | K-13, 14. | 1901 | .....do..... | 19 | 19 | 696 | 30 | .....do..... | ..... | ..... | .....do..... | †15 |
| 1183 | .....do..... | .....do..... | K-13, 14. | 1901 | .....do..... | 19 | 19 | 576 | 27 | Artesian; compressed air. | ..... | ..... | .....do..... | †15 |
| 1184 | .....do..... | .....do..... | K-14.... | 1903 | Bored, 2-inch..... | 21 | 21 | 412 | 29 | Artesian..... | 165.00 | ..... | Stock..... | †4 |
| 1185 | P. G. Labourdette.... | .....do..... | J-13, 14. | 1892 | .....do..... | 18 | 18 | 300? | 25 | .....do..... | ..... | ..... | Domestic..... | ..... |
| 1186 | Bixby Land Co..... | .....do..... | J-13..... | 1900 | Bored, 4-inch..... | 21 | 21 | 410 | 25 | .....do..... | 250.00 | ..... | Irrigation; domestic. | 14 |
| 1187 | .....do..... | .....do..... | J-13..... | 1903 | .....do..... | 22 | 22 | 385 | 28 | .....do..... | 225.00 | ..... | Domestic..... | ..... |
| 1188 | H. H. Bartlett..... | .....do..... | K-13.... | 1893 | Bored, 3-inch..... | 20 | 20 | 250 | 29 | .....do..... | ..... | ..... | Domestic; irrigation. | †1 |
| 1189 | L. Dyke..... | .....do..... | K-13.... | 1895? | Bored 2-inch..... | 20 | 20 | 350? | 27 | .....do..... | ..... | ..... | Domestic..... | ..... |
| 1190 | E. H. Dyer..... | .....do..... | K-13.... | 1897 | .....do..... | 23 | 23 | 512 | 26 | .....do..... | ..... | ..... | Stock; irrigation | Small. |
| 1191 | .....do..... | .....do..... | K-13.... | 1902 | Bored, 3-inch..... | 23 | 23 | 505 | 27 | .....do..... | 272.70 | ..... | Irrigation..... | †9 |
| 1192 | D. R. Proffer..... | Los Coyotes..... | K-13.... | 1897 | Bored, 2-inch..... | 23 | 23 | 306 | .... | Wind..... | 36.00 | ..... | Domestic..... | Small. |
| 1193 | .....do..... | Los Alamitos..... | K-13.... | 1897 | .....do..... | 22 | 22 | 416 | 27 | Artesian..... | 160.00 | ..... | Irrigation..... | Small. |
| 1194 | H. J. Proffer..... | Los Coyotes..... | K-13.... | 1898 | .....do..... | 23 | 23 | 352 | 26 | .....do..... | 110.00 | ..... | Domestic..... | Small. |
| 1195 | Bixby Land Co..... | Los Alamitos..... | J-12..... | 1896 | .....do..... | 23 | 23 | 90 | 22 | .....do..... | 45.00 | ..... | Stock..... | Small. |
| 1196 | .....do..... | .....do..... | J-13..... | 1896 | .....do..... | 25 | 25 | 160 | .... | .....do..... | 60.00 | ..... | Domestic..... | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1197 | Los Alamitos Sugar Co. | Los Alamitos | K-13 | 1896 | Bored, 3-inch | 26 | 26 | 375? | 28 | Artesian | | | Domestic | |
| 1198 | Theo. D. Hewitt | do | L-13 | 1898 | do | 34 | 34 | 300 | 26 | do | | | do | |
| 1199 | do | Los Coyotes | M-13 | 1900 | Bored, 4-inch | 42 | 42 | 480 | 27 | do | | | Irrigation | 15 |
| 1200 | J. W. Swope | do | M-13 | 1868? | Bored, 6-inch | 42 | 42 | 100 | | do | | | Domestic | |
| 1201 | Bixby Land Co | Los Alamitos | L-14 | 1865? | Bored, 9½-inch | 37 | 37 | 100 | 25 | do | | | Not used | |
| 1202 | Gus Hansen | Los Coyotes | M-13 | 1883 | Bored, 7-inch | 44 | 44 | 270 | 26 | do | | | Irrigation | 12 |
| 1203 | do | do | M-13 | | Bored, 2-inch | 43 | 43 | | | do | | | do | Small. |
| 1204 | do | do | M-13 | 1902 | Bored, 12-inch | 42 | 42 | 567 | 32 | do | $1,500.00 | | do | 47 |
| 1205 | Geo. Burrows | do | N-14 | 1898 | Bored, 2-inch | 48 | 48 | | 25 | do | | | Domestic | |
| 1206 | A. Kratzer | do | N-13 | 1898 | Bored, 3-inch | 52 | 52 | 144 | 26 | do | 57.00 | | do | 3 |
| 1207 | Mrs. S. R. Edgerly | do | N-13 | 1895 | Bored, 2-inch | 52 | 52 | 175 | 27 | Artesian, hand | | | do | Small. |
| 1208 | do | do | N-13 | | Bored, 7-inch | 52 | 52 | 420 | 28 | Artesian | | | Stock | Small. |
| 1209 | F. Gruenkey | do | N-13 | 1890? | Bored, 3-inch | 49 | 49 | 300 | 26 | Artesian, hand | | | Domestic | Small. |
| 1210 | do | do | N-13 | 1893 | Bored 2-inch | 48 | 48 | 190 | 27 | Artesian | | | Irrigation | Small. |
| 1211 | H. Krueger | do | N-13 | 1883 | Bored, 10-inch | 48 | 48 | 200 | 27 | do | 250.00 | | Domestic | 1 |
| 1212 | do | do | M-13 | 1899 | Bored, 3-inch | 48 | 48 | 160 | 27 | do | 70.00 | | Irrigation | Small. |
| 1213 | W. H. Musser | do | M-13 | 1896 | Bored, 2-inch | 50 | 50 | 560 | 26 | do | | | do | |
| 1214 | Wm. Elliott | do | M-13 | 1898 | do | 37 | 37 | 300 | 23 | do | | | Not used | |
| 1215 | W. T. Sparks | do | L-13 | 1895 | do | 27 | 27 | 437 | | do | | | Domestic | 3 |
| 1216 | Wm. Elliott | do | M-13 | 1898 | do | 38 | 38 | 300 | | do | | | Not used | |
| 1217 | Cypress school district | do | L-13 | 1896 | do | 27 | 27 | 336 | 28 | do | 125.00 | | Domestic | |
| 1218 | C. L. Damron | do | L-13 | 1896 | do | 31 | 31 | 300 | 28 | do | 150.00 | | Domestic; irrigation. | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1219 | F. Thompson | do | L-13 | 1898 | do | 32 | 32 | 560 | | do | 225.00 | | do | 1 |
| 1220 | L. Deuni | do | L-13 | 1896 | do | 31 | 31 | 577 | 28 | do | 216.37 | | Irrigation | 1 |
| 1221 | A. J. Damron | do | L-12 | 1896 | do | 32 | 32 | 530 | | do | 170.00 | | do | Small. |
| 1222 | do | do | L-12 | 1894 | do | 32 | 32 | 330 | | do | 110.00 | | Domestic; irrigation. | Small. |
| 1223 | do | do | L-12 | 1897 | do | 35 | 35 | 536 | 29 | do | 170.00 | | Irrigation | 5 |
| 1224 | do | do | M-12 | 1897 | do | 39 | 39 | 500 | 29 | do | 150.00 | | Irrigation; stock | 2 |
| 1225 | do | do | M-13 | 1896 | do | 39 | 39 | 300 | 28 | do | 110.00 | | Stock | Small. |
| 1226 | J. C. & J. S. Tucker | do | M-13 | 1890? | do | 44 | 44 | 400? | 26 | do | | | Domestic; irrigation. | Small. |
| 1227 | J. P. Street | do | M-12 | 1895 | do | 44 | 44 | 325 | 28 | do | 130.00 | | Irrigation | Small. |
| 1228 | do | do | M-12 | 1899 | do | 44 | 44 | 525 | 27 | do | 175.00 | | Irrigation; domestic. | †4 |
| 1229 | J. A. Hollingsworth | do | M-13 | 1902 | Bored, 3-inch | 45 | 45 | 580 | 28 | do | | | Irrigation | 2 |
| 1230 | do | do | M-13 | 1900 | Bored, 2-inch | 45 | 45 | 580 | 28 | do | | | Irrigation; domestic. | |
| 1231 | B. F. La Rue | do | M-13 | 1897 | do | 50 | 50 | 270 | 27 | do | | | do | 1½ |
| 1232 | do | do | M-13 | 1897 | Bored, 7-inch | 50 | 50 | 270 | 28 | do | 500.00 | | Irrigation | Small. |
| 1233 | Chas. Burrows | do | M-12 | 1895 | Bored 2-inch | 52 | 52 | 500 | 29 | do | 175.00 | | Domestic | 4 |
| 1234 | D. L. Whitney | do | N-12 | 1895 | do | 53 | 53 | 500 | 28 | do | 175.00 | | do | Small. |
| 1235 | O. P. Bunyard | do | N-13 | 1897 | do | 53 | 53 | 527 | 28 | do | | | do | Small. |
| 1236 | E. P. Wright | do | N-13 | 1883 | Bored, 4-inch | 50 | 50 | 200 | 27 | Hand | | | do | |
| 1237 | L. Seaman | do | N-12 | 1902 | Bored, 3-inch | 58 | 51 | 100 | 25 | do | | | do | |
| 1238 | Geo. Burrows | do | N-12 | 1898 | Bored 2-inch | 53 | 53 | 500 | | Artesian | 150.00 | | do | Small. |
| 1239 | G. B. Hemphill | do | N-12 | 1899 | do | 54 | 53 | 550 | | | 350.00 | | Not used | |
| 1240 | do | do | N-12 | 1894 | do | 54 | 53 | 190 | 26 | Hand | | | Domestic | |
| 1241 | J. W. Miller | do | K-12 | 1888? | Bored, 4-inch | 25 | 25 | 200? | 27 | Artesian | | | do | Small. |
| 1242 | do | do | K-12 | | Bored, 2-inch | 25 | 25 | 200? | | do | | | Stock | Small. |
| 1243 | Chas. Thornton | do | K-12 | 1896 | do | 24 | 24 | 560 | 28 | do | 205.00 | | Domestic; stock | Small. |
| 1244 | do | do | K-12 | 1900 | do | 24 | 24 | 560 | | do | 225.00 | | Irrigation | 5 |
| 1245 | L. Deuni | do | K-13 | 1892 | do | 24 | 24 | 375 | 27 | do | 210.00 | | Domestic | Small. |
| 1246 | Louis Deuni | do | K-13 | 1895 | do | 23 | 23 | 566 | 27 | do | 212.30 | | Irrigation | |
| 1247 | L. H. Harling | do | K-13 | 1892 | Bored, 7-inch | 24 | 24 | 300? | 26 | do | | | Domestic | Small. |
| 1248 | do | do | K-13 | 1898 | Bored, 2-inch | 26 | 26 | 540 | 28 | do | 200.00 | | Irrigation | †1 |
| 1249 | Mrs. J. D. Carter | do | K-12 | 1900 | do | 27 | 27 | 500? | 29 | do | 300.00 | | Domestic | Small. |
| 1250 | do | do | L-13 | 1902 | Bored, 4-inch | 26 | 26 | 575 | 28 | do | | | Irrigation | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1251 | Mrs. E. R. Miller | Los Coyotes | L-12 | 1897 | Bored, 2-inch | 27 | 27 | 340 | 28 | Artesian | $125.00 | | Domestic | Small. |
| 1252 | do | do | L-12 | 1900 | do | 28 | 28 | 590 | 28 | do | 300.00 | | Irrigation | 3 |
| 1253 | do | do | L-12 | 1897 | do | 28 | 28 | 340 | 27 | do | 125.00 | | do | Small. |
| 1254 | J. G. Hannah | do | L-12 | 1895 | do | 28 | 28 | 333 | 27 | do | 150.00 | | do | Small. |
| 1255 | do | do | L-12 | 1897 | do | 28 | 28 | 555 | 27 | do | 250.00 | | do | |
| 1256 | Geo. Nelson | do | K-12 | 1899 | do | 25 | 25 | 548 | 27 | do | | | Domestic; irrigation. | |
| 1257 | W. R. Miller | do | K-12 | 1894 | do | 27 | 27 | 550 | 28 | do | | | Stock | Small. |
| 1258 | C. C. Neff | do | K-12 | 1895 | do | 30 | 30 | 326 | 27 | do | 175.00 | | Domestic | |
| 1259 | Mr. Miller | do | K-12 | 1891 | Bored, 4-inch | 25 | 25 | 330 | | do | 210.00 | | do | Small. |
| 1260 | James Bradie | do | L-12 | 1899 | Bored, 3-inch | 31 | 31 | 550 | 28 | do | 250.00 | | Irrigation | 9 |
| 1261 | J. H. Jackson | do | L-12 | 1894 | do | 31 | 31 | 330 | 27 | do | 170.00 | | do | |
| 1262 | W. R. Burnett | do | L-12 | 1895 | Bored, 2-inch | 32 | 32 | 326 | 27 | do | 150.00 | | Domestic; irrigation. | Small. |
| 1263 | Mrs. Sebastian | do | L-12 | 1895 | do | 35 | 35 | 330 | 27 | do | | | Not used | |
| 1264 | L. Flippen | do | L-12 | 1898 | do | 30 | 30 | 500 | 27 | do | | | Stock | Small. |
| 1265 | J. J. Feagan | do | L-12 | 1898 | do | 36 | 36 | 540 | 28 | do | 300.00 | | Domestic; stock. | 3 |
| 1266 | do | do | L-12 | 1892 | Bored, 7-inch | 36 | 36 | 575 | 28 | do | 1,800.00 | | Irrigation | Small. |
| 1267 | do | do | L-12 | 1902 | Bored, 12-inch | 38 | 38 | 585 | 28 | do | 1,650.00 | | do | 4 |
| 1268 | do | do | L-12 | 1897 | Bored, 2-inch | 38 | 38 | 540 | 28 | do | | | Irrigation; stock | Small. |
| 1269 | do | do | L-12 | 1897 | do | 39 | 39 | 596 | 28 | do | 300.00 | | Domestic | Small. |
| 1270 | J. C. Cawthon | do | M-12 | 1897? | do | 33 | 33 | 500 | | do | | | do | Small. |
| 1271 | J. N. Stockton | do | L-12 | 1902 | do | 41 | 41 | 184 | 26 | Hand | | | do | |
| 1272 | do | do | L-12 | 1898 | do | 42 | 42 | 400? | 27 | Artesian | | | Stock | Small. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1273 | Mrs. R. J. Reeves | do | M-12 | 1894 | do | 45 | 45 | 300 | | Artesian, wind | | | Domestic | | Small. |
| 1274 | C. R. Clausen | do | M 12 | 1900 | do | 46 | 46 | 540 | 29 | Artesian | 270.00 | | Irrigation | | Small. |
| 1275 | do | do | M-12 | 1897 | do | 48 | 48 | 540 | 29 | do | 270.00 | | do | | Small. |
| 1276 | do | do | M-12 | 1897 | do | 48 | 48 | 540 | 29 | do | 270.00 | | do | | Small. |
| 1277 | do | do | M-12 | 1899 | do | 48 | 48 | 280 | 26 | Wind | 140.00 | | Domestic | | |
| 1278 | Mr. A. R. Luedkey | do | M-12 | 1897 | do | 49 | 49 | 540 | | Artesian | 170.00 | | | | Small. |
| 1279 | W. T. Preston | do | M-12 | 1898 | do | 52 | 52 | 500 | 28 | do | 150.00 | | Irrigation | | Small. |
| 1280 | J. L. Preston | do | M-12 | 1898 | do | 53 | 53 | 500 | 29 | do | 140.00 | | Irrigation; domestic. | | Small. |
| 1281 | Wm. Pechstein | do | M-12 | 1893 | do | 53 | 53 | 250 | | do | 175.00 | | Domestic | | Small. |
| 1282 | C. O. Walker | do | N-12 | 1896 | Bored, 5-inch | 55 | 55 | 260+ | | Gas | | | Irrigation | | †50 |
| 1283 | E. R. Holman | do | N-12 | 1893 | Bored, 2-inch | 60 | 59 | 500 | 27 | Wind | | | Domestic | | |
| 1284 | Wm. Abplanalp | do | N-12 | 1892 | do | 60 | 58 | 507 | | Horsepower | | | do | | |
| 1285 | Mrs. Harrison | do | N-12 | 1893 | do | 59 | 59 | 100? | 27 | Hand | | | do | | |
| 1286 | P. Mongofsky | do | N-12 | 1901 | Bored, 3-inch | 60 | 51 | 113 | 30 | Wind | 85.00 | $80.00 | do | | |
| 1287 | Walter Bowen | do | N-12 | 1891? | Bored, 2-inch | 67 | 58 | 180 | | | | | Not used | | |
| 1288 | Mrs. Laura Harrison | do | N-11 | 1892 | do | 68 | 60 | 256 | 28 | Wind | | | Domestic | | |
| 1289 | Geo. N. Frentz | do | N-11 | 1873 | Bored, 7-inch | 66 | 64 | 280 | 29 | Rotary pump | 1,000.00 | | do | | |
| 1291 | J. L. Overton | do | N-11 | 1888 | Bored, 2-inch | 62 | 62 | 500+ | 28 | Artesian | | | Domestic; irrigation. | | Small. |
| 1292 | do | do | N-11 | 1893 | do | 63 | 63 | 280 | | do | | | Irrigation | | |
| 1293 | A. W. Brooks | do | N-12 | 1893 | Bored, 7-inch | 60 | | 80 | 27 | Wind | | | Domestic | | |
| 1294 | John O. Peterson | do | N-12 | 1901 | Bored, 2-inch | 60 | 52 | 80 | 27 | Hand | 30.00 | | do | | |
| 1295 | do | do | N-12 | 1899 | Bored, 3-inch | 61 | 57 | 300 | | Wind | 180.00 | | Irrigation | | |
| 1296 | W. B. Pechstein | do | N-12 | 1903 | do | 57 | 51 | 152 | 27 | do | 75.00 | 20.00 | Domestic | | |
| 1297 | Centralia school district. | do | N-11 | 1897 | Bored, 2-inch | 60 | 60 | 486 | 30 | Artesian | 200.00 | | do | | Small. |
| 1298 | John Terry | do | N-11 | 1900 | Bored, 7-inch, 270 feet; 3-inch, 200 feet. | 59 | 59 | 470 | 28 | do | 500.00 | | Irrigation | | 2 |
| 1299 | do | do | N-11 | 1900 | Bored, 3-inch | 59 | 59 | 475 | 28 | do | 300.00 | | do | | †3 |
| 1300 | do | do | N-11 | 1900 | Bored, 2-inch | 59 | 59 | 475 | 28 | do | 150.00 | | Domestic | | |
| 1301 | Mr. Cordiss | do | N-12 | 1897 | do | 57 | 57 | 290 | | do | | | Irrigation | | Small. |
| 1302 | J. C. Roller | do | M-11 | 1896 | do | 53 | 53 | 200? | 28 | do | | | do | | Small. |
| 1303 | do | do | M-11 | 1896 | do | 27 | 27 | | 27 | do | | | Stock | | Small. |
| 1304 | do | do | M-11 | 1896 | do | 28 | 28 | | 27 | do | | | Irrigation | | Small. |
| 1305 | D. Holder | do | M-11 | 1899 | Hydraulic, 2-inch | 54 | 54 | 510 | 28 | do | | | Domestic | | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1306 | J. Siems | Los Coyotes | N-12 | 1900 | Bored, 2-inch | 58 | 58 | 517 | 28 | Artesian | $200.00 | | Stock | Small. |
| 1307 | do | do | N-12 | 1895 | do | 58 | 58 | 300 | | do | | | Irrigation | Small. |
| 1308 | C. Weber | do | M-12 | 1899 | Bored, 7-inch | 54 | 47? | 104 | | Hand | 80.00 | | Domestic | |
| 1309 | do | do | M-12 | 1897 | Bored, 3-inch | 54 | 54 | 515 | 28 | Artesian | 175.00 | | Stock | Small. |
| 1310 | do | do | M-12 | 1897 | Bored, 2-inch | 54 | 54 | 530 | 28 | do | 180.00 | | Irrigation | Small. |
| 1311 | do | do | M-12 | 1893 | Bored, 7-inch | 54 | 54 | 343 | 28 | | 500.00 | | Not used | |
| 1312 | C. E. Carner | do | N-12 | 1898 | Bored, 2-inch | 58 | 58 | 520 | 27 | Artesian | 300.00 | | do | |
| 1313 | T. M. Laynaehan | do | M-11 | 1897 | do | 50 | 50 | 449 | 27 | do | 157.15 | | Irrigation; domestic. | 1½ |
| 1314 | do | do | M-11 | 1897 | do | 51 | 51 | 515 | 28 | do | 180.25 | | Domestic | Small. |
| 1315 | S. O. Walker | do | M-11 | 1897 | do | 48 | 48 | 292 | 29 | Hand | 120.00 | | do | |
| 1316 | do | do | M-12 | 1897 | do | 50 | 50 | 500? | 31 | Artesian | 230.00 | | Irrigation | Small. |
| 1317 | do | do | M-12 | 1897 | do | 50 | 50 | 500 | | do | 205.00 | | do | Small. |
| 1318 | do | do | M-12 | 1900 | Bored, 3-inch | 50 | 50 | 700 | 27 | do | 450.00 | | do | 3 |
| 1319 | W. D. Gilmore | do | M-12 | 1899 | Bored, 2-inch | 48 | 48 | 590 | 28 | Artesian, wind | 200.00 | | Stock | Small. |
| 1320 | do | do | M-12 | 1903 | do | 47 | 47 | 100 | 28 | Wind | 50.00 | | Domestic | |
| 1321 | Geo. D. Miller | do | M-12 | 1902 | Bored, 10-inch | 47 | 47 | 652 | 29 | Artesian | 1,700.00 | | Irrigation | 1 |
| 1322 | do | do | M-12 | 1890 | Bored, 2-inch | 47 | 47 | 286 | 27 | do | | | Domestic; irrigation. | |
| 1323 | do | do | M-11 | 1896 | do | 47 | 47 | 596 | 27 | do | | | Irrigation | |
| 1324 | G. Dewey | do | M-11 | | Bored, 7-inch | 47 | 47 | | 28 | do | 1,700.00 | | Not used | |
| 1325 | A. Larrecq | do | M-12 | 1902 | Bored, 2-inch | 42 | 40 | 135 | | Hand | 65.00 | | Domestic | |
| 1326 | B. Moullot | do | L-12 | 1899 | do | 39 | 39 | 569 | 28 | Artesian | 175.00 | | Irrigation | Small. |
| 1327 | do | do | L-12 | 1897 | do | 38 | 38 | 542 | 28 | do | 160.00 | | do | Small. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1328 | do | do | L-12 | 1897 | do | 37 | 37 | 531 | 28 | do | 160.00 | | Domestic; irrigation. | Small. |
| 1329 | do | do | L-12 | 1898 | do | 33 | 33 | 596 | 28 | do | 175.00 | | Irrigation | 2 |
| 1330 | E. J. Behnke | do | L-11 | 1892 | Bored, 7-inch | 37 | 37 | 316 | 28 | Hand | 600.00 | | Stock | |
| 1331 | do | do | L-11 | 1898 | Bored, 2-inch | 38 | 38 | 563 | 34 | Artesian | 160.00 | | Not used | |
| 1332 | H. H. Corell | do | L-11 | 1892 | Bored, 7-inch | 51 | 51 | 284 | | do | 420.00 | | Irrigation | |
| 1333 | do | do | L-11 | 1897 | Bored, 2-inch | 37 | 37 | 554 | 28 | do | | | do | Small. |
| 1334 | do | do | L-11 | 1900 | Bored, 3-inch | 37 | 37 | 568 | 30 | do | 305.00 | | do | †9 |
| 1335 | J. P. Moody | do | M-11 | 1900 | do | 35 | 35 | 541 | 28 | do | 300.00 | | do | 5 |
| 1336 | do | do | L-11 | 1885? | Bored, 7-inch | 33 | 33 | 200 | 28 | do | | | Domestic; irrigation. | Small. |
| 1337 | do | do | L-11 | 1898 | Bored, 3-inch | 33 | 33 | 440 | | do | 200.00 | | Irrigation | Small. |
| 1338 | do | do | L-11 | 1901 | do | 33 | 33 | 300 | 28 | do | 175.00 | | do | 2 |
| 1339 | J. F. Sheldon | do | L-12 | 1899 | Bored, 2-inch | 32 | 32 | 550? | 27 | do | | | do | Small. |
| 1340 | do | do | L-12 | 1899 | Bored, 3-inch | 32 | 32 | 550? | 28 | do | | | do | 1½ |
| 1341 | do | do | L-12 | 1893 | Bored, 4-inch | 31 | 31 | 300 | 27 | do | | | Not used | |
| 1342 | Mr. Ermston | do | L-11 | 1894 | Bored, 7-inch | 29 | 29 | | 25 | do | | | Domestic; irrigation. | Small. |
| 1343 | O. Bell | do | K-11 | 1900 | Bored, 3-inch | 29 | 29 | 220 | 28 | do | | | Irrigation | 9 |
| 1344 | B. F. Draper | do | K-11 | 1901 | Bored, 2-inch | 29 | 29 | 315 | | do | 100.00 | | Domestic; irrigation. | †4 |
| 1345 | Mrs. M. A. Geoddel | do | K-12 | 1897 | Bored, 3-inch | 25 | 25 | 541 | 28 | do | 190.00 | | | 9 |
| 1346 | do | do | K-12 | 1870? | Bored, 7-inch | 25 | 25 | 122 | 27 | do | 600.00 | | Domestic | |
| 1347 | do | do | K-12 | 1870? | do | 26 | 26 | 132 | 27 | do | 600.00 | | Irrigation | Small. |
| 1348 | Bloomfield district | do | K-12 | 1889 | Bored, 2-inch | 26 | 26 | 240 | 28 | do | | | Domestic | Small. |
| 1349 | B. J. Jones | do | K-12 | 1886 | Bored, 7-inch | 28 | 28 | 156 | 28 | do | 150.00 | | Domestic; irrigation. | Small. |
| 1350 | do | do | K-12 | 1888 | do | 28 | 28 | 224 | 28 | do | 250.00 | | Irrigation | Small. |
| 1351 | do | do | K-12 | 1901 | Bored, 3-inch | 28 | 28 | 555 | 28 | do | 315.00 | | do | †12 |
| 1352 | J. Swagard | do | K-12 | 1893 | do | 28 | 28 | 500? | | do | 300.00 | | Not used | |
| 1353 | do | do | K-12 | 1898 | do | 28 | 28 | 500 | 27 | do | 300.00 | | Irrigation | |
| 1354 | W. S. Grant | do | K-12 | 1888 | Bored, 7-inch | 26 | 26 | 150 | 27 | do | 150.00 | | Domestic | |
| 1355 | do | do | K-12 | 1901 | Bored, 3-inch | 26 | 26 | 550 | 28 | do | 300.00 | | Irrigation | †8 |
| 1356 | H. Whipple | do | K-12 | 1897? | Bored, 2-inch | 25 | 25 | 350+ | 27 | do | | | Domestic | |
| 1357 | do | do | K-12 | 1898 | Bored, 3-inch | 25 | 25 | 550 | 28 | do | | | Irrigation | 2 |
| 1358 | Fred Smith | do | J-12 | 1896 | Bored, 2-inch | 25 | 25 | 165 | 26 | do | 50.00 | | Domestic | |
| 1359 | do | do | J-12 | 1898 | Bored, 3-inch | 25 | 25 | 201 | 28 | do | 92.00 | | Irrigation | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1360 | Fred Smith | Los Coyotes | J-12 | 1900 | Bored, 3-inch | 25 | 25 | 312 | 27 | Artesian | $180.00 | | Irrigation | †11 |
| 1361 | Columbus Jackson | do | J-12 | 1898 | Bored, 2-inch | 28 | 28 | 173 | 25 | do | 52.00 | | Domestic; irrigation. | |
| 1362 | B F. Draper | do | J-12 | 1898 | do | 28 | 28 | 300 | 27 | do | | | Irrigation | |
| 1363 | do | do | J-12 | 1899 | do | 27 | 27 | 300 | 28 | do | | | Stock | †1 |
| 1364 | do | do | J-12 | 1902 | do | 27 | 27 | 300 | 28 | do | | | | Small. |
| 1365 | L. A. Goodrich | do | J-12 | 1900 | Bored, 3-inch | 25 | 25 | 230 | 24 | do | | | Domestic; irrigation. | |
| 1366 | Anson Woodon | do | J-12 | 1898 | Bored, 2-inch | 28 | 28 | 300 | 24 | do | 150.00 | | Domestic; stock | |
| 1367 | H. L. Gordon | do | J-12 | | do | 27 | 27 | | 24 | do | | | Domestic | |
| 1368 | do | do | J-12 | | Bored, 7-inch | 27 | 27 | | | do | | | Stock | Small. |
| 1369 | do | Los Cerritos | I-12 | | Bored, 4-inch | 27 | 27 | | 24 | do | | | Irrigation | †1 |
| 1370 | do | do | I-12 | | Bored, 10-inch | 28 | 28 | | 26 | do | | | do | Small. |
| 1371 | do | do | I-12 | | Bored, 4-inch | 28 | 28 | | 27 | do | | | do | †1 |
| 1372 | do | do | I-12 | | do | 28 | 28 | | 27 | do | | | do | †1 |
| 1373 | do | do | I-12 | | do | 28 | 28 | | 26 | do | | | do | †1 |
| 1374 | do | do | I-12 | | Bored, 2-inch | 29 | 29 | | 21 | do | | | do | Small. |
| 1375 | do | do | I-12 | | Bored, 4-inch | 29 | 29 | | 21 | do | | | do | †1 |
| 1376 | do | do | I-12 | | do | 29 | 29 | | 21 | do | | | do | †1 |
| 1377 | do | do | I-12 | | do | 29 | 29 | | 21 | do | | | do | †1 |
| 1378 | do | do | I-12 | | do | 27 | 27 | | 26 | do | | | do | †2 |
| 1379 | do | do | J-12 | | do | 26 | 26 | | 24 | do | | | do | 4 |
| 1380 | do | do | J-12 | | do | 26 | 26 | | 26 | do | | | do | 4 |
| 1381 | do | do | J-12 | | do | 26 | 26 | | 26 | do | | | do | 4 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1382 | W. J. Woolin | Los Coyotes | J-11 | 1894 | Bored, 2-inch | 31 | 31 | 240 | 22 | do | 135.00 | | Domestic | Small. |
| 1383 | do | do | J-11 | 1886 | Bored, 7-inch | 31 | 31 | 240 | 26 | do | 300.00 | | Stock | Small. |
| 1384 | S. L. Leighton | do | J-11 | 1885 | do | 31 | 31 | 243 | 25 | do | | | Domestic | Small. |
| 1385 | W. Donnelley | do | J-11 | 1897 | Bored, 2-inch | 31 | 31 | 180 | 25 | do | | | do | |
| 1386 | B. H. Norton | do | J-11 | 1897 | Bored, 3-inch | 31 | 31 | 185 | 24 | do | 64.75 | | do | Small. |
| 1387 | C. Dorety | Los Cerritos | I-11 | 1900 | Bored, 4-inch | 32 | 32 | 300 | | do | 200.00 | | Irrigation | 11 |
| 1388 | do | do | I-11 | 1900 | Bored, 2-inch | 32 | 32 | 180 | | do | 70.00 | | | 4 |
| 1389 | W. M. Delano | Los Coyotes | K-11 | 1899 | do | 30 | 30 | 250 | | do | | | Domestic | †6 |
| 1390 | J. T. McCann | do | J-11 | 1899 | do | 29 | 29 | 180 | 27 | do | | | Domestic; irrigation. | |
| 1391 | do | do | J-11 | 1899 | do | 29 | 29 | 180 | 29 | do | | | Irrigation | Small. |
| 1392 | J. S. McDonald | do | K-12 | 1899 | do | 28 | 28 | 550 | 27 | do | | | Irrigation; domestic. | 4 |
| 1393 | A. Von Gruinegen | do | K-12 | 1885 | Bored, 7-inch | 28 | 28 | | 26 | do | | | Stock | Small. |
| 1394 | do | do | K-12 | 1898 | Bored, 3-inch | 28 | 28 | 550? | 26 | do | | | Irrigation | 8 |
| 1395 | do | do | K-12 | 1893? | Bored, 7-inch | 28 | 28 | | | do | | | do | 1 |
| 1396 | R. M. Foote | do | K-11 | 1876 | do | 28 | 28 | 236 | 27 | do | | | Stock | Small. |
| 1397 | do | do | K-11 | 1885? | do | 28 | 28 | 219 | 27 | do | | | Domestic | Small. |
| 1398 | do | do | K-11 | 1899 | Bored, 3-inch | 28 | 28 | 591 | | do | | | Irrigation | 3 |
| 1399 | Francis Pearce | do | K-11 | 1876 | Bored, 7-inch | 30 | 30 | 275 | 28 | Horsepower | | | do | |
| 1400 | do | do | K-11 | 1880 | Bored, 4-inch | 30 | 30 | 164 | | Artesian | 240.00 | | do | |
| 1401 | M. Stanfield | do | K-11 | 1896 | Bored, 2-inch | 31 | 31 | 80 | 26 | do | | | Domestic | Small. |
| 1402 | do | do | K-11 | 1896 | do | 31 | 31 | 300 | | do | | | Stock | Small. |
| 1403 | B. Chubbic | do | K-11 | 1885 | Bored, 7-inch | 32 | 32 | 200 | 26 | do | | | Domestic | Small. |
| 1404 | F. E. Green | do | J-11 | 1898 | Bored, 3-inch | 34 | 34 | 175 | | do | 70.00 | | Stock | Small. |
| 1405 | R. G. Ravenscroft | do | J-11 | 1892 | Bored, 7-inch | 33 | 33 | 130 | 25 | Artesian, wind | | | Domestic; irrigation. | Small. |
| 1406 | do | do | K-11 | 1897 | Bored, 3-inch | 31 | 31 | 190 | | Artesian | | | Irrigation | 3 |
| 1407 | do | do | K-11 | 1897 | Bored, 2-inch | 31 | 31 | 190 | | do | | | do | 2 |
| 1408 | F. Hancock | do | J-11 | 1901 | Bored, 3-inch | 31 | 31 | 200 | | do | | | do | 2 |
| 1409 | J. H. Crittenden | do | J-11 | 1897 | Bored, 2-inch | 33 | 33 | 550 | 29 | do | 247.50 | | Domestic | |
| 1410 | Jim Mushrust | do | K-11 | 1893 | Bored, 7-inch | 33 | 33 | 180 | 24 | do | | | do | Small. |
| 1411 | do | do | K-11 | 1899 | Bored, 2-inch | 35 | 35 | 350? | 28 | do | | | Irrigation | Small. |
| 1412 | Benj. Chubbic | do | K-11 | 1897 | Bored, 3-inch | 32 | 32 | 330 | 28 | do | 160.00 | | do | 1 |
| 1413 | Mrs. M. E. Frankle | do | K-11 | 1898 | Bored, 2-inch, 30 feet; 3-inch, 270 feet. | 32 | 32 | 300 | | do | | | do | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1414 | Thos. Moyle | Los Coyotes | K-11 | 1895 | Bored, 2-inch | 33 | 33 | 181 | 24 | Artesian | $100.00 | | Domestic; irrigation. | 2 |
| 1415 | R. W. Bingham | do | K-11 | 1899 | do | 34 | 34 | 190 | 27 | do | 100.00 | | Domestic | |
| 1416 | do | do | K-11 | 1892 | Bored, 7-inch | 34 | 34 | 237 | 22 | do | 575.00 | | Irrigation | 7 |
| 1417 | do | do | K-11 | 1899 | Bored, 2¾-inch | 34 | 34 | 200 | | do | 125.00 | | do | |
| 1418 | do | do | K-11 | 1899 | do | 34 | 34 | 200 | 27 | do | 125.00 | | do | Small. |
| 1419 | do | do | K-11 | 1900 | Bored, 7-inch | 34 | 34 | 295 | | do | 675.00 | | do | 7 |
| 1420 | Judge Willis | do | K-11 | 1900 | Bored, 2-inch | 33 | 33 | 100? | 27 | do | | | Domestic | |
| 1421 | Geo. Apgar | do | K-11 | 1881 | Bored, 7-inch | 31 | 31 | 200 | 27 | do | 300.00 | | Stock | †1 |
| 1422 | do | do | K-11 | 1897 | Bored, 3-inch | 32 | 32 | 165 | 27 | do | 85.00 | | Irrigation | 9 |
| 1423 | do | do | K-11 | 1897 | Bored, 2-inch | 32 | 32 | 235 | 27 | do | 125.00 | | do | 3 |
| 1424 | do | do | K-11 | 1894 | Bored, 7-inch | 34 | 34 | 316 | 26 | do | 435.00 | | do | 1 |
| 1425 | Perry Moore | do | L-11 | 1901 | Bored, 3-inch | 35 | 35 | 550 | 26 | do | | | do | 8 |
| 1426 | Mrs. Hollister | do | L-11 | 1901 | do | 38 | 38 | 318 | 25 | do | 225.00 | | do | 8 |
| 1427 | M. Williams | do | L-11 | 1893 | Bored, 7-inch | 38 | 38 | 210 | 25 | do | 274.25 | | Domestic | Small. |
| 1428 | do | do | L-11 | 1900 | Bored, 3-inch | 38 | 38 | 318 | 26 | do | 225.00 | | | 8 |
| 1429 | do | do | L-11 | 1900 | do | 37 | 37 | 320 | 26 | do | 225.00 | | Irrigation | 5 |
| 1430 | C. L. Chamberlain | do | L-11 | 1901 | do | 39 | 39 | 520 | | do | 289.00 | | Stock | Small. |
| 1431 | O. J. Chamberlain | do | L-11 | 1903 | Bored, 4-inch | 41 | 41 | 286 | | do | 268.00 | | Irrigation | 25 |
| 1432 | G. S. Chamberlain | do | L-11 | 1902 | do | 42 | 42 | 266 | 26 | do | 265.00 | | do | 8 |
| 1433 | E. A. Gotterba | do | L-11 | 1896 | Bored, 2-inch | 37 | 37 | 200+ | 27 | do | | | Stock | Small. |
| 1434 | R. B. Luther | do | L-11 | 1902 | do | 38 | 38 | 87 | 28 | do | 75.00 | | Domestic; irrigation. | 1 |
| 1435 | C. Salisbury | do | M-11 | 1897 | do | 39 | 39 | 150 | 27 | do | | | do | 1 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1436 | W. Triplett | do | M-11 | 1897 | Bored, 3-inch | 45 | 45 | 600 | 26 | do | | | Stock | Small. |
| 1437 | do | do | M-11 | 1897 | do | 45 | 45 | 600 | 27 | do | | | do | Small. |
| 1438 | do | do | M-11 | 1891 | Bored, 7-inch | 45 | 45 | 200 | 27 | do | | | do | Small. |
| 1439 | J. A. Campbell | do | M-11 | 1891 | Bored, 4-inch | 50 | 50 | 96 | | do | | | Not used | |
| 1440 | do | do | M-11 | 1900 | Bored, 3-inch | 50 | 50 | 250 | | do | 84.00 | | Irrigation | |
| 1441 | do | do | M-11 | 1900 | Bored, 2-inch | 50 | 50 | 464 | 25 | do | 153.00 | | Domestic; irrigation. | |
| 1442 | J. W. Mann | do | M-11 | 1902 | Bored, 4-inch | 53 | 53 | 168 | 27 | do | 80.00 | | Irrigation | 14 |
| 1443 | Arch Stoddard | do | M-11 | 1902 | Bored | 54 | 54 | 240 | 28 | do | 140.00 | | do | 2 |
| 1444 | Mr. G. M. Hoard | do | N-11 | 1896 | Bored, 2-inch | 66 | 66 | 550 | 28 | do | | | Stock | Small. |
| 1445 | Wm. McCarthy | do | N-11 | 1893 | Driven, 1-inch | 68 | 60? | 100 | 25 | Wind | | $100.00 | Domestic | |
| 1446 | W. Gusel | do | N-11 | 1902 | Bored, 2-inch | 67 | 57 | 82 | 26 | Hand | | | do | |
| 1447 | J. Mitchell | do | N-11 | 1895 | Bored, 7-inch | 67 | 61 | 450 | 27 | Gas | 1,000.00 | 600.00 | Irrigation | 48 |
| 1448 | do | do | N-11 | 1897 | do | 67 | 61 | 250 | 27 | do | 300.00 | | do | |
| 1449 | Lyman & Niger | do | N-10, 11 | 1888? | do | 65 | 61 | 230 | 26 | do | | | do | |
| 1450 | do | do | N-10, 11 | 1902 | Bored, 12-inch, 230 feet; 10-inch, 230 feet. | 65 | 61 | 460 | 27 | do | 860.00 | | do | †150 |
| 1451 | do | do | N-10 | 1901 | Bored, 10-inch | 65 | 61 | 100 | 27 | do | 166.00 | | do | |
| 1452 | do | do | N-10 | 1900 | Bored, 7-inch | 68 | 61 | 278 | | Wind | 400.00 | | Domestic | |
| 1453 | E. A. Niger | do | N-10 | 1895? | Bored, 2-inch | 70 | 67 | 300+ | 27 | Hand | | | do | |
| 1454 | Mr. Shoemaker | do | N-10 | 1890? | Bored, 7-inch | 69 | 67 | | | do | | | Not used | |
| 1455 | J. W. McKenny | do | N-10 | 1891 | Bored, 4-inch | 66 | 66 | 320 | 26 | Artesian | | | Stock; irrigation. | Small. |
| 1456 | R. C. Archibald | do | N-10 | 1901 | do | 65 | 65 | 120 | 26 | Wind | 35.00 | 100.00 | Domestic | |
| 1457 | do | do | N-10 | 1895 | Bored, 2-inch | 64 | | 422 | | Artesian | 135.00 | | Not used | |
| 1458 | J. W. McKenny | do | N-10 | 1886 | Bored, 7-inch | 65 | 65 | 202 | | Artesian, hand | | | Domestic | Small. |
| 1459 | do | do | N-10 | 1897 | Bored, 4-inch | 65 | 65 | 407 | 26 | Artesian | 250.00 | | Irrigation | †1 |
| 1460 | do | do | N-10 | 1903 | Bored, 12-inch | 65 | 65 | 400 | 27 | do | 900.00 | | do | |
| 1461 | do | do | N-10 | 1897 | Bored, 2-inch | 68 | 68 | 403 | | do | 175.00 | | do | Small. |
| 1462 | Geo. E. Dutton | do | N-11 | 1891 | Bored, 4-inch | 62 | 58 | 275 | 25 | Wind | | | Domestic | |
| 1463 | J. M. Robertson | do | N-10 | 1890 | Bored, 7-inch | 59 | 54 | 308 | 26 | Hand | 600.00 | | do | |
| 1464 | R. E. Ibbetson | do | N-10 | 1902 | Bored, 10-inch | 61 | 61 | 460 | 27 | Gas | 1,000.00 | 700.00 | Irrigation | †80 |
| 1465 | do | do | N-10 | 1895 | Bored, 2-inch | 61 | 61 | 460 | 28 | Artesian | | | do | |
| 1466 | do | do | N-11 | | do | 56 | 56 | | 28 | do | | | Stock | Small. |
| 1467 | Mr. Stone | do | N-11 | | Bored, 3-inch | 57 | 57 | | 26 | do | | | do | Small. |
| 1468 | Isner & McCloud | do | N-10 | 1885 | Bored, 7-inch | 58 | 58 | | 26 | do | | | Domestic | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1469 | Penelope Calder | Los Coyotes | N-10 | 1898 | Bored, 3-inch | 57 | 57 | 420 | 26 | Artesian | $200.00 | | Stock | Small. |
| 1470 | do | do | N-10 | 1896 | do | 57 | 57 | 420 | | do | 200.00 | | Not used | |
| 1471 | do | do | M-10 | 1898 | do | 53 | 53 | 420 | 29 | do | 200.00 | | Domestic | |
| 1472 | Dr. Jas. Calder | do | M-10 | 1898 | do | 52 | 25 | 420 | 28 | do | 200.00 | | do | |
| 1473 | do | do | N-10 | 1898 | do | 56 | 56 | 420 | | do | 200.00 | | Not used | |
| 1474 | do | do | N-10 | 1898 | do | 51 | 51 | 420 | 29 | do | | | do | |
| 1475 | Rev. J. Cameron | do | M-10 | | do | 51 | 51 | 400? | 32 | do | | | Stock | Small. |
| 1476 | R. Loritt | do | M-10 | 1895 | Bored, 2-inch | 52 | 52 | 300— | 27 | Wind | | | Domestic; stock | |
| 1477 | J. A. McDonald | do | M-10 | 1883 | Bored, 7-inch | 49 | 49 | 180 | 29 | Artesian | | | Domestic | Small. |
| 1478 | do | do | M-10 | 1883? | do | 51 | 51 | 200? | | do | | | Stock | Small. |
| 1479 | do | do | M-10 | 1896 | Bored, 3-inch | 49 | 49 | 407 | 29 | do | 225.00 | | do | Small. |
| 1480 | do | do | M-10 | 1896 | do | 50 | 50 | 450 | 29 | do | 240.00 | | do | Small. |
| 1481 | do | do | M-10 | 1883 | Bored, 7-inch | 50 | 50 | | | do | | | Not used | |
| 1482 | do | do | M-9 | 1902 | Hydraulic, 3-inch | 51 | 51 | 197 | | do | 100.00 | | Irrigation | 3 |
| 1483 | do | do | M-10 | 1902 | do | 50 | 50 | 237 | | do | 125.00 | | do | 2 |
| 1484 | do | do | M-10 | 1902 | Bored, 4-inch | 50 | 50 | 230 | 30 | do | 150.00 | | do | 1 |
| 1485 | do | do | M-9 | 1883 | Bored, 7-inch | 56 | 56 | 250 | | do | | | Stock | 1 |
| 1486 | W. H. Hall | do | M-10 | 1902 | Bored, 12-inch | 45 | 45 | 286 | | Gas | 550.00 | $900.00 | Irrigation | 50 |
| 1487 | do | do | M-10 | 1900 | Bored, 7-inch | 46 | 46 | 286 | | Artesian | 250.00 | | Not used | |
| 1488 | do | do | L-10 | 1900 | do | 45 | 45 | 135 | 27 | do | 190.00 | | Domestic; irrigation. | 6 |
| 1489 | W. H. Forbes | do | L-11 | 1902 | Hydraulic, 3-inch | 42 | 42 | 575 | 27 | do | 300.00 | | Irrigation | Small. |
| 1490 | do | do | L-11 | 1900 | do | 42 | 42 | 600 | 27 | do | 350.00 | | do | Small. |
| 1491 | do | do | L-11 | 1903 | Hydraulic, 2-inch | 42 | 42 | 280 | 27 | do | 125.00 | | Domestic | 1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1492 | G. S. McWilliams | do | L-11 | 1898 | Hydraulic, 3-inch. | 42 | 42 | 393 | 28 | do | 210.00 | | Irrigation | 3 |
| 1493 | do | do | L-11 | 1898 | do | 43 | 43 | 280 | | do | 128.00 | | do | 2 |
| 1494 | do | do | L-11 | 1896 | Bored, 2-inch | 43 | 43 | 280 | 27 | do | 125.00 | | Domestic | |
| 1495 | do | do | L-11 | 1897 | Hydraulic, 3-inch. | 43 | 43 | 378 | 27 | do | 208.00 | | Domestic; irrigation. | 2 |
| 1496 | do | do | L-11 | 1903 | Bored, 4-inch | 43 | 43 | 282 | 27 | do | 170.00 | | Irrigation | 2 |
| 1497 | M. C. Chase | do | L-11 | 1898 | do | 42 | 42 | 615 | 30 | do | 300.00 | | do | |
| 1498 | do | do | L-11 | 1902 | Hydraulic, 3-inch. | 42 | 42 | 280 | | do | 168.00 | | do | 3 |
| 1499 | do | do | L-11 | 1903 | Bored, 4-inch | 42 | 42 | 280 | | do | 196.00 | | do | 4 |
| 1500 | Mr. Haskell | do | L-10 | | Bored, 3-inch | 44 | 44 | | 26 | do | | | do | Small. |
| 1501 | Mr. Shneck | do | L-10 | | Bored, 7-inch | 43 | 43 | | 29 | do | | | Domestic; irrigation. | |
| 1502 | do | do | L-10 | | Hydraulic, 2-inch. | 43 | 43 | | | do | | | Not used | |
| 1503 | E. Heimerte | do | L-10 | 1883 | Bored, 6-inch | 39 | 39 | 280 | 26 | do | 500.00 | | Domestic | Small. |
| 1504 | Mr. Omstead | do | L-10 | 1883 | Bored, 7-inch | 41 | 41 | 250 | 27 | do | | | do | Small. |
| 1505 | J. W. Alexander | do | K-10 | 1892 | Hydraulic, 2-inch. | 41 | 41 | 235 | 23 | do | 150.00 | | Domestic; irrigation. | 1 |
| 1506 | do | do | K-10 | 1895 | do | 41 | 41 | 230 | 24 | do | 150.00 | | Domestic | Small. |
| 1507 | J. F. Thompson | do | K-10 | 1897 | do | 41 | 41 | 500 | 36 | do | | | Domestic; irrigation. | 2 |
| 1508 | do | do | K-10 | 1898 | do | 41 | 41 | 500 | 32 | do | | | Irrigation | 3 |
| 1509 | W. Hancock | do | K-10 | 1888? | Bored, 7-inch | 41 | 40 | | 23 | Hand | | | Domestic | |
| 1510 | A. J. Wells | do | K-11 | 1888? | do | 37 | 37 | 200 | 25 | Artesian | | | do | Small. |
| 1511 | Carey & McKinley | do | K-11 | 1897 | Hydraulic, 2-inch. | 37 | 37 | 200 | 32 | do | | | do | Small. |
| 1512 | do | do | K-11 | 1896 | Bored, 7-inch | 37 | 37 | 200 | 30 | do | | | Irrigation | 1 |
| 1513 | do | do | K-11 | 1898 | Hydraulic, 2-inch. | 37 | 37 | 500 | 31 | do | | | do | 2 |
| 1514 | do | do | K-11 | 1898 | do | 37 | 37 | 200 | | do | | | Not used | |
| 1515 | L. Thornton | do | J-11 | 1896 | do | 38 | 38 | 200 | | do | 66.00 | | Domestic | |
| 1516 | do | do | J-11 | 1901 | Bored, 5-inch | 38 | 38 | 200 | | do | 175.00 | | Irrigation | 9 |
| 1517 | do | do | K-11 | 1901 | do | 39 | 39 | 200 | 23 | do | | | do | 9 |
| 1518 | A. S. Manefee | do | J-11 | 1893 | Bored, 4-inch | 38 | 38 | 200 | | Gas, artesian | | 430.00 | Domestic; irrigation. | 3 |
| 1519 | John Severs | do | J-11 | 1885 | Bored, 7-inch | 38 | 38 | 189 | 22 | Artesian | 237.50 | | Domestic | 12 |
| 1520 | F. T. Morse | do | J-11 | 1892 | do | 37 | 37 | 243 | 23 | do | | | Irrigation | 19 |
| 1521 | W. L. Campbell | do | J-11 | 1893 | Hydraulic, 3-inch. | 35 | 35 | 156 | 55 | do | | | Domestic | |
| 1522 | do | do | J-11 | 1903 | Bored, 7-inch | 35 | 35 | 303 | 22 | do | 500.00 | | Irrigation | 12 |
| 1523 | W. A. Campbell | do | J-11 | 1875 | do | 39 | 39 | 203 | 22 | do | 650.00 | | Domestic | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1524 | W. A. Campbell | Los Coyotes | J-11 | 1874 | Bored, 7-inch | 40 | 40 | 262 | 22 | Artesian | $850.00 | | Domestic | Small. |
| 1525 | J. E. Courtney | do | I-11 | 1875? | do | 42 | 42 | 180+ | 23 | Wind, artesian | | | do | Small. |
| 1526 | John Keir | Los Cerritos | I-11 | 1883 | do | 40 | 40 | 228 | 23 | Artesian | | | do | †1 |
| 1527 | Mrs. M. Butler | do | I-11 | 1897 | Hydraulic, 2-inch | 41 | 41 | 185 | | do | | | do | |
| 1528 | Mr. Gordon | Los Coyotes | I-11 | | do | 43 | 43 | | 23 | do | | | Stock | Small. |
| 1529 | J. C. Smith | do | K-10 | 1897? | do | 42 | 42 | | 23 | do | | | Domestic | Small. |
| 1530 | N. D. Robinson | do | K-10 | 1892 | do | 40 | 40 | 195 | 22 | do | 100.00 | | Stock | 4 |
| 1531 | do | do | K-10 | 1877 | Bored, 7-inch | 40 | 40 | 127 | 23 | Hand, artesian | 150.00 | | Domestic | †2 |
| 1532 | do | do | K-10 | 1894 | Hydraulic, 3-inch | 39 | 39 | 185 | | Artesian | 100.00 | | Irrigation; stock | 5 |
| 1533 | Mr. Dolley | do | K-10 | 1897? | Hydraulic, 2-inch | 44 | 44 | 175 | 25 | do | | | Not used | |
| 1534 | F. H. Purdy | do | K-10 | 1888? | Bored, 7-inch | 42 | 42 | 180 | 23 | do | | | Domestic; irrigation. | Small. |
| 1535 | do | do | K-10 | 1899 | Hydraulic, 3-inch | 41 | 41 | 140 | | do | | | Irrigation | |
| 1536 | Mr. Hurley | do | K-10 | 1898 | Hydraulic, 2-inch | 43 | 43 | 140 | 22 | do | | | Domestic | |
| 1537 | C. Dohn | do | J-10 | 1888 | Bored, 7-inch | 42 | 42 | 200 | | do | 300.00 | | do | |
| 1538 | do | do | K-10 | 1898 | Hydraulic, 2-inch | 40 | 40 | 175 | 25 | do | 51.00 | | Irrigation | †2 |
| 1539 | do | do | J-10 | 1897 | do | 42 | 42 | 175 | | do | 51.00 | | Not used | |
| 1540 | B. A. Epperly | do | J-10 | 1897 | Bored, 7-inch | 44 | 44 | 200 | 22 | do | | | Irrigation | |
| 1541 | do | do | J-10 | 1897 | Hydraulic, 2-inch | 44 | 44 | 200 | 22 | do | | | do | 1 |
| 1542 | Epperly estate | do | J-10 | 1895 | do | 42 | 42 | 560 | | do | | | Domestic; irrigation. | 1 |
| 1543 | do | do | J-10 | 1893? | Bored, 7-inch | 42 | 42 | 300 | 22 | do | | | Irrigation | Small. |
| 1544 | do | do | J-10 | 1896 | Hydraulic, 2-inch | 40 | 40 | 250 | 22 | do | | | Not used | |
| 1545 | do | do | J-10 | 1896 | do | 40 | 40 | 560 | 30 | do | | | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1546 | S. A. Frampton | do | J-10 | 1875? | Bored, 7-inch | 42 | 42 | 200+ | 22 | do | | | Domestic | 12 |
| 1547 | do | do | J-10 | 1891 | do | 40 | 40 | 200+ | 22 | do | | | Irrigation | 2 |
| 1548 | L. Carse | do | J-10 | 1877 | do | 43 | 43 | 252 | | do | 525.00 | | Stock | Small. |
| 1549 | do | do | J-10 | 1897 | Hydraulic, 2-inch | 43 | 43 | 142 | 25 | do | 50.00 | | Domestic | |
| 1550 | F. T. Morse | do | J-10, 11 | 1892 | Bored, 7-inch | 41 | 41 | 197 | 23 | do | | | Domestic; irrigation. | |
| 1551 | E. P. Morrison | do | J-10 | 1897 | Hydraulic, 2-inch | 44 | 44 | 176 | 23 | do | 55.00 | | Domestic | Small. |
| 1552 | Crown Creamery Co. | do | J-10 | 1900 | do | 45 | 45 | 176 | 22 | do | | | do | |
| 1553 | N. Gregory | do | I-10 | | Bored, 7-inch | 46 | 46 | 464 | 22 | do | | | do | Small. |
| 1554 | do | do | I-10 | | Hydraulic, 2½-inch | 45 | 45 | 170 | 23 | do | | | Irrigation | Small. |
| 1555 | Mr. Russell | do | I-10 | | Hydraulic, 2-inch | 42 | 42 | | 22 | do | | | Domestic | Small. |
| 1556 | C. M. Buck | do | I-10 | 1889 | Bored, 7-inch | 45 | 45 | 180 | 22 | do | | | do | Small. |
| 1557 | J. E. Stones | do | I-10 | 1902 | Hydraulic, 3-inch | 46 | 46 | | 21 | do | | | Domestic; irrigation. | 4 |
| 1558 | Mr. White | do | I-10 | 1892? | Hydraulic, 2-inch | 44 | 44 | | 24 | do | | | Stock | Small. |
| 1559 | L. C. Butler | do | I-10 | 1890 | do | 46 | 46 | 113 | 25 | do | | | Domestic | Small. |
| 1560 | W. A. Sackett | Los Cerritos | I-10 | 1891 | do | 45 | 45 | 180 | 25 | do | | | Domestic; irrigation. | 2 |
| 1561 | J. W. Hansard | do | H-1 | 1897 | do | 42 | 42 | 180 | 26 | do | | | Stock | Small. |
| 1562 | Mrs. Richardson | do | H-11 | | do | 43 | 43 | 180 | 25 | Hand, artesian | | | Domestic | Small. |
| 1563 | Alexander Watson | do | H-10 | 1895 | do | 45 | 45 | 160 | 26 | do | | | Domestic; irrigation. | |
| 1564 | Mr. Burger | do | H-10 | 1897 | do | 47 | 47 | 250 | 22 | Artesian | 85.00 | | Domestic | Small. |
| 1565 | N. Jish | do | H-10 | 1899 | do | 47 | 47 | 633 | 22 | do | 300.00 | | Irrigation | |
| 1566 | J. A. Goodlin | do | H-10 | 1895 | do | 47 | 47 | 131 | 28 | do | 36.00 | | Domestic; irrigation. | Small. |
| 1567 | S. E. Garber | do | H-10 | 1896 | Bored, 7-inch | 50 | 50 | 600+ | 27 | Wind, artesian | 1,000.00 | | Irrigation | |
| 1568 | do | do | H-10 | 1902 | Bored, 12-inch | 50 | 46 | 130 | | Not raised | 200.00 | | Not used | |
| 1569 | S. T. Carum | do | H-10 | 1895 | Hydraulic, 2-inch | 50 | 50 | 180 | 25 | Wind, artesian | 80.00 | | Domestic | Small. |
| 1570 | H. W. Carum | do | I-10 | 1880 | Bored, 7-inch | 48 | 46 | 190 | 25 | Hand | 250.00 | | Stock | |
| 1571 | do | do | I-10 | 1900 | Bored, 3¾-inch | 48 | 47 | 135 | | do | 115.00 | | Domestic | |
| 1572 | do | do | I-10 | 1900 | do | 48 | 47 | 135 | | Not raised | 115.00 | | Not used | |
| 1573 | W. L. Campbell | Los Coyotes | I-10 | 1886 | Bored, 4-inch | 49 | 49 | 160 | 27 | Artesian | | | Stock | Small. |
| 1574 | do | do | I-10 | 1895 | Bored, 7-inch | 49 | 49 | 150 | 27 | do | | | do | Small. |
| 1575 | do | do | I-10 | 1893 | Hydraulic, 2-inch | 50 | 50 | 150 | 22 | do | | | Domestic | Small. |
| 1576 | do | do | I-10 | 1893 | do | 50 | 50 | 150 | 26 | do | | | Stock | Small. |
| 1577 | do | do | I-9, 10 | 1895 | Bored, 7-inch | 51 | 51 | 160 | | do | | | do | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1578 | L. E. Dean | Los Coyotes | I-10 | | Bored, 7-inch | 51 | 51 | 215 | 23 | Hand, artesian | | | Domestic | |
| 1579 | J. B. Ashby | do | I-10 | 1898 | do | 51 | 51 | 278 | 23 | Artesian | | | Domestic; irrigation. | 1 |
| 1580 | I. L. de Clereq | do | I-10 | 1900 | Hydraulic, 2-inch. | 50 | 50 | 78 | | do | $35.00 | | Domestic | Small. |
| 1581 | John Paull | do | I-10 | 1879 | Bored, 7-inch | 49 | 49 | 300 | 23 | Hand, artesian | | | do | Small. |
| 1582 | D. C. Ewing | do | I-10 | | do | 48 | 48 | | 22 | do | | | do | |
| 1583 | P. T. Ward | do | I-10 | 1880? | do | 47 | 47 | 300 | 22 | Artesian | | | do | Small. |
| 1584 | E. P. Meggs | do | I-10 | 1901? | Driven, 1¼-inch | 47 | 47 | 70 | 22 | Hand | | | do | |
| 1585 | C. C. Wright | do | I-10 | 1893 | Hydraulic, 3-inch. | 53 | 53 | 330 | 22 | Artesian | | | do | Small. |
| 1586 | John Brooker | do | I-10 | 1895 | Hydraulic, 2-inch. | 52 | 52 | 100 | 23 | Hand, artesian | | | do | |
| 1587 | S. R. Ibbotson | do | J-10 | 1894 | do | 52 | 52 | 176 | | Artesian | 100.00 | | do | |
| 1588 | Artesian school district. | do | J-10 | 1886 | Bored, 4-inch | 47 | 47 | 200 | | do | | | do | |
| 1589 | Artesian Christian Church. | do | J-10 | 1893 | Hydraulic, 2-inch. | 48 | 48 | 127 | 23 | do | | | do | Small. |
| 1590 | Wm. Gamble | do | J-10 | 1900 | do | 52 | 52 | 85 | 24 | do | | | do | Small. |
| 1591 | do | do | J-10 | 1893? | Bored, 6-inch | 51 | 51 | 300 | | do | | | Irrigation | |
| 1592 | M. E. Rurviance | do | J-10 | 1888? | Bored, 4-inch | 50 | 50 | 125 | 24 | do | | | Domestic | Small. |
| 1593 | Methodist Episcopal parsonage. | do | J-10 | | Hydraulic, 2-inch. | 47 | 47 | | 23 | do | | | Domestic; irrigation. | 1 |
| 1594 | C. B. Scott | do | J-10 | 1893? | Bored, 7-inch | 46 | 46 | 333 | 22 | do | | | Domestic | |
| 1595 | G. R. Frampton | do | J-10 | 1883 | do | 45 | 45 | | 23 | do | | | do | |
| 1596 | W. H. Smith | do | J-10 | 1896 | Hydraulic, 2-inch. | 45 | 45 | 212 | 22 | do | | | Not used | |
| 1597 | L. J. Stone | do | J 10 | 1893 | do | 45 | 45 | 181 | 23 | Hand, artesian | 125.75 | | Domestic | Small. |
| 1598 | Mr. Morris | do | J-10 | 1888? | Bored, 8-inch | 41 | 44 | 300 | 23 | Artesian | | | do | Small. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1599 | I. Nicholls | do | J-10 | 1888? | Bored, 7-inch | 43 | 43 | 225 | | do | | | Stock | |
| 1600 | do | do | J-10 | 1900 | Hydraulic, 3-inch | 43 | 43 | 531 | 23 | do | 300.00 | | Irrigation; domestic. | Small. |
| 1601 | G. R. Frampton | do | J-10 | 1900 | Hydraulic, 2-inch | 47 | 47 | 267 | 22 | do | 120.00 | | Domestic | |
| 1602 | C. A. Linge | do | J-10 | 1894? | do | 48 | 48 | 248 | 21 | do | | | do | Small. |
| 1603 | James Gillespie | do | J-10 | 1892 | Bored, 7-inch | 48 | 48 | 220 | 22 | do | 350.00 | | do | |
| 1604 | do | do | K-10 | 1900 | Hydraulic, 2-inch | 58 | 58 | 190 | 23 | do | 91.00 | | do | |
| 1605 | do | do | J-9 | 1895 | Hydraulic, 3-inch | 44 | 44 | 268 | 33 | Hand, artesian | | | do | Small. |
| 1606 | Mrs. J. Purdy | do | J-10 | 1895 | Hydraulic, 2-inch | 49 | 49 | 140 | 23 | Artesian | | | do | |
| 1607 | do | do | J-10 | 1896 | do | 49 | 49 | 150 | 23 | do | | | do | |
| 1608 | H. D. Andrews | do | J-10 | 1897 | do | 50 | 50 | 130 | 23 | do | | | do | 1 |
| 1609 | T. H. Johnson | do | J-9 | 1896 | do | 50 | 50 | 240 | 22 | do | | | do | |
| 1610 | do | do | J-9 | 1896 | Hydraulic, 3-inch | 50 | 50 | 190 | 23 | do | | | Irrigation | Small. |
| 1611 | R. Carter | do | J-10 | 1896 | Hydraulic, 2-inch | 50 | 50 | | 23 | do | | | Domestic | |
| 1612 | Mrs. M. Turner | do | J-9 | 1895 | do | 51 | 51 | 150 | | Wind, artesian | | $150.00 | do | |
| 1614 | D. S. Drisbach | do | J-10 | 1894 | do | 47 | 47 | 190 | 23 | Gas, artesian | 125.00 | 300.00 | Irrigation | 10 |
| 1615 | T. P. Patterson | do | J-10 | 1896 | do | 48 | 48 | 150 | 24 | Artesian | 50.00 | | Domestic | |
| 1616 | do | do | J-10 | 1899 | Bored, 4-inch | 48 | 48 | 130 | | do | 130.00 | | Not used | |
| 1617 | J. B. Hollingsworth | do | J-10 | 1898 | Hydraulic, 2-inch | 47 | 47 | 150 | 24 | do | 45.00 | | Domestic | |
| 1618 | S. G. Woodward | do | J-10 | 1895 | Bored, 7-inch | 46 | 46 | 300 | | do | 300.00 | | Irrigation | Small. |
| 1619 | do | do | K-10 | 1899 | Hydraulic, 3-inch | 47 | 47 | 151 | 26 | Wind, artesian | 47.00 | | Domestic; irrigation. | Small. |
| 1620 | Mr. Gould | do | K-10 | 1898 | Hydraulic, 2-inch | 46 | 46 | 600 | | Artesian | | | Not used | |
| 1621 | D. Thatcher | do | K-10 | 1893 | Bored, 2-inch | 48 | 48 | 154 | 26 | do | 100.00 | | Domestic | Small. |
| 1622 | Mrs. Meador | do | K-10 | | Bored, 7-inch | 47 | 47 | 500+ | 24 | do | | | do | |
| 1623 | Mrs. M. E. Thomas | do | K-10 | 1880? | do | 47 | 47 | 200+ | | Hand | | | do | |
| 1624 | Mrs. Ella Pierce | do | K-10 | 1885? | do | 44 | 44 | 260? | 23 | Artesian, hand | | | do | Small. |
| 1625 | J. F. Smith | do | K-10 | 1893 | do | 47 | 47 | 125 | 23 | Artesian | 250.00 | | Domestic; irrigation. | |
| 1626 | A. M. Costner | do | K-10 | 1899 | Bored, 2-inch | 47 | 47 | 217 | 28 | do | 72.00 | | Domestic | Small. |
| 1627 | J. A. Smith | do | L-10 | 1893 | Bored, 6-inch | 48 | 48 | 170 | 25 | do | 200.00 | | Irrigation | 8 |
| 1628 | J. B. Alexander | do | L-10 | 1885 | Bored, 7-inch | 50 | 50 | 336 | 28 | do | 500.00 | | Domestic | 1 |
| 1629 | Mr. Johnson | do | K-10 | | Bored, 2-inch | 43 | 43 | | 32 | do | | | Irrigation | 1 |
| 1630 | do | do | K-10 | | do | 42 | 42 | | 36 | do | | | do | Small. |
| 1631 | H. D. Andrews | do | K-10 | 1901 | Bored, 3-inch | 42 | 42 | | 30 | do | 150.00 | | do | 2 |
| 1632 | J. A. Smith | do | L-10 | 1883 | Bored, 4-inch | 47 | 47 | 124 | | do | 100.00 | | Stock | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1633 | J. A Smith | Los Coyotes | L-10 | 1893 | Bored, 6-inch | 48 | 48 | 200 | | Artesian | $300.00 | | Irrigation | 4 |
| 1634 | Sullivan estate | do | L-10 | 1895 | Bored, 3-inch | 48 | 48 | 300 | 28 | do | | | Not used | |
| 1635 | do | do | L-10 | 1901 | do | 47 | 47 | 280 | 45 | do | 160.00 | | Irrigation | 12 |
| 1636 | J. B. Monroe | do | L-10 | 1898 | do | | | 137 | 27 | do | | | do | 3 |
| 1637 | do | do | L-10 | 1898 | do | 47 | 47 | 145 | 27 | do | 79.75 | | do | 1 |
| 1638 | do | do | L-9 | 1885 | Bored, 7-inch | 52 | 52 | 145 | 27 | do | 150.00 | | Domestic | Small. |
| 1639 | Mr. Pug Rhodes | do | L-10 | 1891? | Bored, 4-inch | 48 | 48 | 140 | 26 | do | | | do | Small |
| 1640 | J. B. Teel | do | L-10 | 1897 | Bored, 2-inch | 48 | 48 | 200 | 27 | do | 60.00 | | Domestic; irrigation. | |
| 1641 | do | do | L-10 | 1893 | do | 48 | 48 | 140 | 28 | do | | | Stock | Small. |
| 1642 | do | do | L-10 | 1895 | Bored, 3-inch | 46 | 46 | 600 | 35 | do | | | Irrigation | Small. |
| 1643 | Mr. Zeus | do | M-10 | 1895? | Bored, 2-inch | 49 | 49 | 170 | 28 | do | | | do | 4 |
| 1644 | R. G. French | do | L-10 | 1897 | do | 49 | 49 | 140 | 27 | do | 37.50 | | Domestic | Small. |
| 1645 | do | do | L-10 | 1888 | Bored, 4-inch | 49 | 49 | 140 | 26 | do | 160.00 | | Irrigation | 1 |
| 1646 | do | do | L-10 | 1897 | Bored, 2-inch | 49 | 49 | 140 | 27 | do | 37.50 | | Domestic | Small. |
| 1647 | W. E. Dorety | do | L-9 | 1878 | Bored, 7-inch | | | 150 | 28 | do | | | do | Small. |
| 1648 | J. R. Mitchell | do | M-9 | 1901 | Bored, 3-inch | 52 | 52 | | 27 | do | | | Irrigation | 6 |
| 1649 | do | do | M-10 | | Bored, 2-inch | 51 | 51 | | | do | | | do | 4 |
| 1650 | C. A. Hudgins | do | L-9 | 1891 | do | 58 | 58 | 90? | | Hand, artesian | | | Domestic | |
| 1651 | do | do | L-9 | 1897? | do | 57 | 57 | 335 | 51 | Artesian | | | Stock | 2 |
| 1652 | Dr. Crandall | do | L-9 | 1888 | Bored, 7-inch | 56 | 56 | 130 | 27 | do | | | do | Small. |
| 1653 | T. M. Dillman | do | L-9 | 1893 | Bored, 2-inch | 54 | 54 | 108 | 25 | Hand | 65.00 | | Domestic | |
| 1654 | John Baker | do | L-9 | 1885? | Bored, 7-inch | 56 | 56 | 114 | | Artesian | | | Stock | Small. |
| 1655 | A. L. Smith | do | L-9 | 1899 | Bored, 2-inch | 57 | 57 | 103 | 25 | do | 50.00 | | Domestic; stock. | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1656 | G. H. Lillard | do | L-9 | 1884 | Bored, 7-inch | 45 | 45 | 150 | 30 | Artesian, hand | | | Domestic | Small. |
| 1657 | do | do | L-9 | 1894? | Bored, 2-inch | 45 | 45 | 605 | 24 | Artesian | | | Irrigation | 4 |
| 1658 | Mrs. M. E. Robbins | do | L-10 | 1883? | Bored, 4-inch | 51 | 51 | 3307 | 26 | do | | | Domestic | Small. |
| 1659 | D. H. Lillard | do | L-9 | 1893 | Bored, 2-inch | 57 | 57 | 406 | 21 | do | | | Domestic; irrigation. | 4 |
| 1660 | do | do | L-9 | 1883 | Bored, 7-inch | 59 | 59 | 385 | 52 | do | 1,000.00 | | Stock | Small. |
| 1661 | J. L. Dougherty | do | L-10 | 1891 | Bored, 2-inch | 51 | 51 | 485 | | do | 240.00 | | Irrigation | 4 |
| 1662 | do | do | L-9, 10 | 1891 | do | 52 | 52 | 485 | 40 | do | 242.50 | | Domestic | Small. |
| 1663 | do | do | L-9 | 1903 | do | 54 | 52 | 125 | | do | 50.00 | | Stock | |
| 1664 | C. W. Clauton | do | L-9 | 1888 | Bored, 7-inch | 60 | 60 | 180 | 22 | do | | | Domestic | Small. |
| 1665 | do | do | L-9 | 1897 | Bored, 2-inch | 67 | 67 | 365 | 39 | do | 150.00 | | Stock | Small. |
| 1666 | P. H. Vedder | do | K-9 | 1897 | do | 60 | 60 | 130 | 22 | do | 130.00 | | Domestic | 2 |
| 1667 | James A. Smith | do | K-9 | 1877 | Bored, 7-inch | 53 | 53 | 293 | 23 | do | | | Domestic; irrigation. | 1 |
| 1668 | John Masten | do | K-9 | 1888 | do | 59 | 59 | 160 | 22 | do | | | Domestic | Small. |
| 1669 | do | do | K-9 | 1895 | Bored, 2-inch | 59 | 59 | 415 | 32 | do | | | Irrigation | Small. |
| 1670 | do | do | K-9 | 1895 | do | 60 | 60 | 420 | 33 | do | | | do | 1 |
| 1671 | Chas. Grimm | do | K-9 | 1898 | do | 58 | 58 | 467 | 19 | do | 250.00 | | do | 5 |
| 1672 | J. A. Smith | do | K-9 | 1876 | Bored, 7-inch | 53 | 53 | 350 | 22 | do | 1,000.00+ | | Domestic | Small. |
| 1673 | do | do | K-9 | 1891 | do | 53 | 53 | 558 | 22 | do | 1,000.00 | | Stock | Small. |
| 1674 | M. E. Purdy | do | K-9 | 1896 | do | 51 | 51 | | 26 | do | | | do | Small. |
| 1675 | Mr. M. H. Meyers | do | K-10 | 1894 | Bored, 2-inch | 48 | 48 | 135 | 27 | Hand, artesian | | | Domestic | Small. |
| 1676 | J. Swagard | do | K-9 | 1898 | do | 53 | 53 | 140 | 27 | Artesian | | | do | Small. |
| 1677 | L. C. Misom | do | K-9 | 1893 | do | 54 | 54 | 185 | 25 | Artesian, hand | 65.00 | | Domestic; irrigation | Small. |
| 1678 | F. M. McCreary | do | K-9 | 1893? | do | 54 | 54 | 145 | 23 | Artesian | | | Domestic | Small. |
| 1679 | do | do | K-9 | 1903 | Bored, 4-inch | 53 | 53 | 145 | | Gas, artesian | 106.00 | $400.00 | Irrigation | †35 |
| 1680 | C. A. Abbott | do | J-9 | 1902 | Bored, 2-inch | 51 | 51 | 70 | 22 | Artesian | 70.00 | | Domestic | Small. |
| 1681 | M. C. Porter | do | J, K-9 | 1897 | Bored, 3-inch | 50 | 50 | 130 | | do | 65.00 | | Domestic | Small. |
| 1682 | J. W. Bell | do | J-9 | 1895 | Bored, 2-inch | 52 | 52 | 550 | 23 | do | | | Stock | Small. |
| 1683 | do | do | J-9 | 1895 | do | 53 | 53 | 500? | 20 | do | | | do | Small. |
| 1684 | J. B. Benham | do | J-9 | 1897 | do | 54 | 54 | 600? | 22 | do | | | Domestic | Small. |
| 1685 | G. H. Clark | do | J-9 | 1899 | do | 54 | 54 | 600 | | do | | | Irrigation | Small. |
| 1686 | do | do | J-9 | 1888? | Bored, 7-inch | 54 | 54 | 200 | 23 | do | | | Domestic | |
| 1687 | John Gillispie | do | J-9 | 1897 | Bored, 2-inch | 53 | 53 | 140+ | | do | 60.00 | | do | |
| 1688 | Mrs. Matthews | do | J-9 | 1895? | do | 56 | 56 | | 24 | do | | | do | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1689 | F. M. Schnabel | Los Coyotes | J-9 | 1900? | Bored, 2-inch | 58 | 58 | 130 | 24 | Artesian | $75.00 | | Domestic; irrigation. | |
| 1690 | Mr. Holingsworth | do | I-9 | | do | 58 | 58 | | 21 | do | | | Not used | |
| 1691 | R. E. Dolley | do | I-9 | 1888? | Bored, 7-inch | 57 | 57 | 230? | 25 | do | 500.00 | | Domestic | Small. |
| 1692 | do | do | I-9 | | Bored, 2-inch | 56 | 56 | 570 | 24 | do | | | Irrigation | Small. |
| 1693 | M. L. Black | do | J-9 | | do | 53 | 53 | | 23 | do | | | Domestic | Small. |
| 1694 | E. J. Collins | do | I-10 | 1873? | Bored, 7-inch | | | | 25 | Hand | | | do | |
| 1695 | Frank Seppi | do | I-9 | | Bored, 2-inch | 58 | 58 | | 26 | Artesian | | | do | Small. |
| 1696 | L. M. Moore | do | I-9 | 1897 | do | 58 | 57 | 156 | 26 | Hand | | | do | |
| 1697 | do | do | I-9 | 1899 | do | 57 | 57 | 588 | | Artesian | | | Irrigation | Small. |
| 1698 | Frank Seppi | do | I-9 | 1898 | Bored, 4-inch | 64 | 64 | 495 | | do | | | do | |
| 1699 | A. W. Ellis | do | I-9 | 1891 | Bored, 2-inch | 57 | 56 | 220 | 23 | Hand | | | Domestic | |
| 1700 | Artesia graveyard | do | I-9 | 1880? | Bored, 7-inch | 56 | 53 | 190 | 25 | Wind | | | Irrigation | |
| 1701 | S. T. Corum | do | I-9 | 1880 | Bored, 2-inch | 54 | 54 | 200 | 28 | Artesian | | | Domestic | Small. |
| 1702 | J. Hay | do | I-9 | | Bored, 7-inch | 53 | 53 | | | do | | | Stock | Small. |
| 1703 | C. D. Thompson | do | I-9 | 1884? | do | 56 | 56 | 121 | 28 | Artesian, hand | | | Domestic | Small. |
| 1704 | Mr. McFarland | do | H-10 | 1888? | Bored, 4-inch | 53 | 53 | 140 | 30 | Hand | | | do | |
| 1705 | do | do | H-10 | 1901 | Bored, 3-inch | 53 | 53 | 600 | 23 | Artesian | | | Irrigation | 3 |
| 1706 | John Zinn | Los Cerritos | H-10 | 1880? | Bored, 4-inch | 52 | 52 | 144 | | do | | | Stock | Small. |
| 1707 | G. A. Brown | do | H-9 | 1895 | Bored, 2-inch | 56 | 56 | 128 | 30 | Wind | | | Domestic | |
| 1708 | Jacob P. Thompson | do | H-9 | 1878? | Bored, 7-inch | 55 | 55 | 130 | 31 | do | 800.00 | | do | Small. |
| 1709 | do | do | H-9 | 1884 | Bored, 4-inch | 55 | 55 | 128 | | | 108.00 | | Not used | |
| 1710 | W. T. Gann | do | H-9 | 1898 | Bored, 2-inch | | | 608 | 23 | Artesian | 350.00 | | Domestic | Small. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1711 | do | do | H-9 | 1888? | do | 57 | | 150 | 31 | Hand | | | do | | |
| 1712 | Page estate | Los Coyotes | I-8 | | do | | | | 34 | do | | | do | | |
| 1713 | S. T. Corum | do | H-8 | 1878 | Bored, 7-inch | 65 | 65 | 111 | | Artesian | | | Stock | | |
| 1714 | H. Vogt | do | I-8 | 1898? | Bored, 2-inch | 68 | 68 | | 34 | Hand, artesian | | | Domestic | | |
| 1715 | S. Holgate | do | I-8 | | Bored, 7-inch | | | 104 | 33 | do | | | do | | |
| 1716 | S. Washburn | do | I-8 | 1801 | do | 65 | 59 | 177 | 32 | do | | | do | | |
| 1717 | Chas. Young | do | I-9 | 1900 | Bored, 3-inch | 63 | 63 | 120 | | Wind, artesian | 66.00 | $150.00 | do | | |
| 1718 | W. Dolly | do | I-9 | 1875? | Bored, 7-inch | | | 277 | 26 | do | | | do | | |
| 1719 | do | do | I-9 | 1898 | Bored, 4-inch | | | 133 | | Artesian | | | Stock | | |
| 1720 | O. D. Thompson | do | I-9 | 1902 | Bored, 2-inch | | | 200 | 29 | Wind | 50.00 | 200.00 | Domestic | | |
| 1721 | do | do | I-9 | 1875? | Bored, 7-inch | 61 | 61 | 200 | | Artesian, hand | | | Stock | | |
| 1722 | do | do | I-8 | 1878? | do | 66 | 65 | 200 | | Artesian | | | do | | |
| 1723 | J. Vance | do | I-9 | 1878 | do | 59 | 58 | 200 | 32 | Hand | | | Domestic | | |
| 1724 | J. F. Brown | do | I-9 | 1897 | Bored, 2-inch | 64 | 64 | 150 | | Artesian, wind | | 160.00 | do | Small. | |
| 1725 | Mr. McKinney | do | I-9 | 1902 | Bored, 3-inch | 62 | 62 | 158 | 25 | Artesian | | | do | 8 | |
| 1726 | do | do | I-9 | 1902 | do | 52 | 52 | 116 | 26 | do | 200.00 | | Stock | | |
| 1727 | do | do | I-9 | 1903 | do | 64 | 64 | 135 | 27 | do | | | Irrigation | 8 | |
| 1728 | do | do | I-9 | 1898 | do | 64 | 64 | 485 | | do | 175.00 | | do | 5 | |
| 1729 | Mr. Copeland | do | I-9 | | Bored, 2-inch | 65 | 65 | 130 | 33 | do | | | Domestic; irrigation | Small. | |
| 1730 | H. W. White | do | J-9 | 1893 | do | 64 | 64 | 125? | 26 | do | | | Domestic | Small. | |
| 1731 | W. L. Coward | do | J-9 | 1900 | Bored, 4-inch | 62 | 62 | 190 | 23 | do | 80.00 | | Stock: irrigation. | 1 | |
| 1732 | do | do | J-9 | 1884 | do | 62 | 62 | 190 | 23 | do | 125.00 | | Domestic | 1 | |
| 1733 | Frank Gillespie | do | J-9 | 1887 | Bored, 7-inch | 57 | 57 | 200 | 24 | do | | | do | | |
| 1734 | W. H. Matthews | do | J-9 | 1895? | Bored, 2-inch | 51 | 51 | 86 | 22 | do | 86.00 | | Domestic; irrigation. | Small. | |
| 1735 | Chas. West | do | J-9 | | do | 56 | 56 | | | do | | | Irrigation | Small. | |
| 1736 | do | do | J-9 | | do | 55 | 55 | | 25 | do | | | Domestic | | |
| 1737 | Chas. Young | do | J-10 | 1900 | Bored, 3-inch | 51 | 51 | 192 | 24 | do | | | Irrigation | Small. | |
| 1738 | Frank Leeper | do | J-8 | 1878? | Bored, 7-inch | 65 | 65 | 163 | 24 | Wind | | | Domestic; irrigation. | Small. | |
| 1739 | do | do | J-8 | 1902 | Bored, 2-inch | 66 | 66 | 117 | 24 | Artesian | 35.00 | | Stock | †1 | |
| 1740 | F. W. Hackney | do | J-8 | | Bored, 7-inch | 69 | 69 | 136 | 24 | Wind | | | Domestic | | |
| 1741 | do | do | J-8 | | Bored, 2-inch | 59 | 59 | 123 | | Artesian | | | Irrigation | Small. | |
| 1742 | J. W. Donovan | do | J-8 | 1888? | Bored, 4-inch | 69 | 69 | 132 | 25 | Horsepower, artesian. | | | Domestic; irrigation. | Small. | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1743 | J. W. Donovan | Los Coyotes | J-8 | 1895? | Bored, 2-inch | | | 140? | | Artesian | | | Stock | Small. |
| 1744 | McKinney & Searight | do | J-8 | 1885 | Bored, 7-inch | 72 | 70 | 150 | 23 | Hand | | | Domestic | |
| 1745 | Mrs. A. M. Sproule | do | I, J-8 | 1878 | do | 70 | | 130 | 24 | Artesian | | | Irrigation | Small |
| 1746 | do | do | J-8 | 1899 | Bored, 3-inch | 67 | 67 | | | do | | | do | 3 |
| 1747 | do | do | I-8 | 1896 | Bored, 2-inch | 69 | 69 | 137 | 32 | do | $48.00 | | Domestic | Small. |
| 1748 | W. L. Coward | do | J-9 | 1899 | Bored, 3-inch | | | 190 | 24 | do | 80.00 | | Irrigation | 8 |
| 1749 | H. Gotterba | do | I-8 | 1896 | Bored, 2-inch | 68 | 68 | 240 | 33 | Artesian, hand | | | Domestic | Small. |
| 1750 | W. C. Sproul | do | I-8 | 1873 | Bored, 7-inch | 69 | 69 | 200? | 31 | Hand, artesian | | | do | |
| 1751 | do | do | I-8 | 1893 | Bored, 2-inch | 70 | 70 | 450 | 23 | Artesian | 120.00 | | Domestic; irrigation. | Small. |
| 1752 | C. G. Bremond | do | I-8 | 1889 | Bored, 4-inch | 70 | 70 | 133 | 33 | Hand, artesian | 110.00 | | do | |
| 1753 | D. J. Buehn | do | I-8 | 1876 | Bored, 7-inch | 68 | 68 | 185 | | Wind, artesian | 700.00 | $650.00 | Domestic | |
| 1754 | Perris Moore | do | I-8 | 1903 | Bored, 3-inch | | | 172 | 31 | Hand | | | do | |
| 1755 | J. S. Eloit | do | I-8 | 1893 | Bored, 2-inch | 76 | 75 | 150 | 37 | do | 90.00 | | do | |
| 1756 | Newriver school district. | do | I-7 | 1898 | do | 83 | 82 | 105 | 42 | do | | | do | |
| 1757 | W. P. Tibbett | do | I-7 | 1883? | Bored, 4-inch | 81 | 81 | 120 | | Hand, artesian | | | do | |
| 1758 | John McLawton | do | I-7 | 1900 | do | 80 | 80 | 120 | 37 | Artesian | | | Stock | Small. |
| 1759 | Mrs. Stienhart | do | I-8 | 1878? | Bored, 6-inch | 51 | 51 | 120? | 29 | do | | | do | Small. |
| 1760 | Robert Sackett | Los Cerritos | H-8 | 1902 | Bored, 12-inch | 68 | 68 | 104 | | Gas | 165.00 | | Irrigation | 60 |
| 1761 | do | do | H-8 | 1900 | Bored, 2-inch | 64 | 64 | 100 | | Hand, artesian | 80.00 | | Domestic | |
| 1762 | M. H. Holland | Los Coyotes | I-8 | 1884 | Bored, 7-inch | 73 | 73 | 130 | | Steam, artesian | | | Irrigation | Small. |
| 1763 | W. B. Pendleton estate | Los Cerritos | H-8 | 1885 | do | 63 | 63 | 150 | 31 | Artesian | | | Not used | |
| 1764 | John McLawton | Los Coyotes | H-7 | 1888 | Bored, 4-inch | 77 | 77 | 120 | 41 | Hand | | | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1765 | Steve Strong | do | I-8 | | Bored, 2-inch | 77 | 76 | 107 | | Wind | | | Stock | | |
| 1766 | do | do | I 7 | | do | 82 | 81 | 110? | 43 | do | | | Domestic | | |
| 1767 | S. Washburn | do | I-7 | 1885? | Bored, 4-inch | 83 | 81 | 100? | 31 | Gas | | 125.00 | do | Small. |
| 1768 | E. Clark | do | I-8 | | Bored, 2-inch | 76 | 76 | 130? | 32 | Artesian | | | Stock | Small. |
| 1769 | Frank Coulon | do | I-7 | 1896 | do | 83 | 82 | 100? | | do | | | do | |
| 1770 | do | do | I-7 | 1883? | Bored, 3-inch | 85 | 83 | 100 | 34 | Wind | | 117.00 | Domestic | |
| 1771 | Mr. Thorn | do | I-7 | 1883? | Bored, 7-inch | 88 | 85 | 175 | | Hand, gas | | | Domestic; irrigation. | |
| 1772 | Mrs. Strong | do | I-7 | | Bored, 2-inch | 83 | 83 | | 22 | Artesian | | | Stock; irrigation. | Small. |
| 1773 | David Bullis | do | J-7 | 1903 | do | 86 | | 110 | | Hand | 40.00 | | Domestic | |
| 1774 | Mrs. C. Burmiller Hickey. | do | J-8 | 1885 | Bored, 7-inch | 81 | 81 | 435 | 21 | Wind | 1,400.00 | | do | |
| 1775 | Mr. Swagard | do | J-8 | 1890? | Bored, 2-inch | 76 | | 150 | 29 | Hand | | | do | |
| 1776 | Geo. Heberle | do | J-8 | | Bored, 7-inch | 81 | 67 | 50? | 42 | do | | | do | |
| 1777 | W. F. Williamson | do | J-8 | 1883? | do | 69 | 69 | 140? | 27 | Artesian | | | do | Small. |
| 1778 | do | do | J-8 | | do | 70 | 70 | 127 | 29 | do | | | Stock | Small. |
| 1779 | C. Nottingham | do | J-8 | 1878 | do | 68 | 68 | 200 | 26 | do | | | do | Small. |
| 1780 | Mrs. M. Evans | do | J-8 | 1885 | do | 67 | 67 | 180 | 26 | do | | | do | 1 |
| 1781 | A. Nottingham | do | K-8 | 1901 | Bored, 2-inch | 69 | 69 | 762 | | do | 350.00 | | Irrigation | |
| 1782 | do | do | K-8 | 1895 | do | 70 | 70 | 386 | 22 | do | 125.00 | | Not used | |
| 1783 | W. M. Allison | do | J-9 | 1885 | Bored, 7-inch | 62 | 62 | 260 | 23 | Wind, artesian | 500.00 | | Domestic | |
| 1784 | do | do | J-9 | 1898 | Bored, 3-inch | 62 | 62 | 416 | 22 | Artesian | 200.00 | | Stock | Small. |
| 1785 | do | do | J-9 | 1873 | Bored, 7-inch | 62 | 61 | 150 | | | | | Not used | |
| 1786 | Mrs. James | do | K-9 | | do | 61 | 61 | 150 | 29 | Hand | | | Domestic | |
| 1787 | Mr. Porter | do | J-9 | 1880? | do | 58 | 58 | 400? | 29 | Artesian, wind | | | Domestic; stock. | Small. |
| 1788 | H. F. Drake | do | J-9 | 1902 | Bored, 2-inch | 60 | 60 | 629 | 20 | Artesian | 290.00 | | Irrigation | 4 |
| 1789 | John Aultman | do | K-9 | 1894 | do | 58 | 58 | 190 | | do | | | Domestic | |
| 1790 | Joe Clanton | do | K-9 | 1895 | Bored, 7-inch | 57 | 57 | 190 | 36 | do | | | do | |
| 1791 | J. F. Weaver | do | K-9 | 1898 | Bored, 2-inch | 58 | 58 | 612 | 20 | do | 350.00 | | Irrigation; domestic. | 5 |
| 1792 | H. F. Drake | do | K-9 | 1893 | Bored, 7-inch | 62 | 62 | 429 | 21 | do | 1,000.00 | | Stock | Small. |
| 1793 | do | do | K-9 | 1880 | do | 62 | 62 | 200 | 22 | Artesian, wind | | | Domestic | Small. |
| 1794 | Mr. McGentis | do | K-9 | 1875 | do | 64 | 64 | 130 | 27 | Hand | | | do | |
| 1795 | J. G. Denman | do | K-9 | 1888 | do | 65 | 65 | 160 | 22 | Wind, artesian | 250.00 | | do | |
| 1796 | do | do | K-9 | 1899 | Bored, 2-inch | 65 | 65 | 400 | 20 | Artesian | 200.00 | | Stock | Small. |
| 1797 | do | do | K-9 | 1874 | Bored, 7-inch | 68 | 67 | 312 | 24 | Gas | 200.00 | 400.00 | Irrigation | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1798 | J. G. Denman | Los Coyotes | K-9 | 1899 | Bored, 2-inch | 68 | 68 | 408 | 21 | Artesian | $200.00+ | | Irrigation | Small. |
| 1799 | do | do | K-9 | 1898 | Bored, 3-inch | 68 | 68 | 379 | 20 | do | 200.00+ | | Irrigation; stock | Small. |
| 1800 | do | do | K-9 | 1888 | Bored, 7-inch | 67 | 67 | 130 | | Wind, artesian | 140.00 | | Stock | |
| 1801 | J. W. Clanton | do | K-9 | 1896 | Bored, 2-inch | 66 | 66 | 155 | 25 | do | 60.00 | $190.00 | Domestic | Small. |
| 1802 | do | do | K-9 | 1896 | do | 66 | 66 | 365 | 21 | Artesian | 200.00 | | Stock | Small. |
| 1803 | do | do | K-9 | 1896 | do | 66 | 66 | 385 | 20 | do | | | do | Small. |
| 1804 | J. W. Fowler | do | K-8 | 1894 | do | 67 | 67 | 400 | 20 | do | 225.00 | | Domestic | Small. |
| 1805 | do | do | K-8 | 1895 | Bored, 3-inch | 67 | 67 | 385 | | do | 300.00 | | Not used | |
| 1806 | Mr. Brooks | do | K-8 | 1883 | Bored, 7-inch | 68 | 68 | 175 | 27 | Artesian, hand | | | Domestic; stock | Small. |
| 1807 | C. Nottingham | do | K-8 | 1878? | do | 73 | 73 | 175 | 27 | Wind | | 300.00 | Domestic | |
| 1808 | do | do | K-8 | 1897 | Bored, 2-inch | 71 | 71 | 719 | | Artesian | 275.00 | | Irrigation | 5 |
| 1809 | do | do | K-8 | 1895 | do | 71 | 71 | 160 | 22 | Wind, artesian | 70.00 | | Irrigation; stock | Small |
| 1810 | J. L. Davee | do | K-8 | 1883 | Bored, 6-inch | 73 | 70 | 200? | 31 | Hand | | | Domestic | |
| 1811 | Jeff. Elliott | do | K-8 | | Bored, 2-inch | 71 | 69 | 75 | 33 | do | | | do | |
| 1812 | do | do | K-8 | | do | 72 | 72 | 580 | 21 | do | | | Irrigation | Small. |
| 1813 | do | do | K-8 | | do | 72 | 72 | 580 | | do | | | do | 4 |
| 1814 | M. Noble | do | K-8 | 1899 | do | 77 | 77 | 691 | 22 | do | 271.00 | | do | |
| 1815 | do | do | K-8 | 1893 | Bored, 7-inch | 77 | 77 | 490 | 20 | do | 1,100.00 | | Domestic; stock | †2 |
| 1816 | do | do | K-8 | 1902 | Bored, 2-inch | 77 | 77 | 491 | 20 | do | 240.00 | | Stock | †4 |
| 1817 | J. T. Hallett | do | K-8 | 1894 | do | 73 | 73 | 300 | 21 | do | | | Domestic | Small. |
| 1818 | do | do | K-8 | 1885 | Bored, 7-inch | 73 | | 100 | | do | 100.00 | | do | |
| 1819 | Theo Gillette | do | L-8 | 1893? | Bored, 2-inch | 70 | 70 | 300? | 21 | Artesian, hand | | | do | Small. |
| 1820 | J. A. Smith | do | K-8 | 1895 | do | 65 | 65 | 150 | 26 | Artesian | | | do | Small. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1821 | Augustus F. Sproul | do | K-9 | 1877 | Bored, 7-inch | 62 | 62 | 300 | 28 | do | 800.00 | | Domestic; irrigation. | 2 |
| 1822 | do | do | K-9 | 1897 | Bored, 2-inch | 64 | 64 | 385 | 21 | do | 225.00 | | Stock | Small. |
| 1823 | J. H. Gwin | do | K-9 | 1890? | do | 64 | 64 | 150 | 23 | do | | | Domestic | Small. |
| 1824 | C. Grimm | do | K-9 | 1900 | do | 62 | 62 | 422 | 27 | do | 127.00 | | do | Small. |
| 1825 | do | do | K-9 | 1901 | do | 62 | 62 | 75 | | do | 55.00 | | Stock | Small. |
| 1826 | W. Ramp | do | K-9 | 1897 | do | 66 | 66 | 150 | | do | | | Domestic; irrigation. | Small. |
| 1827 | Simon Stiffler | do | K-9 | 1891 | do | 64 | 64 | 100 | 27 | do | | | Domestic | Small. |
| 1828 | T. L. Hungerford | do | L-9 | 1894 | Bored, 4-inch | 65 | 65 | 100 | 27 | do | | | Domestic; irrigation. | Small. |
| 1829 | do | do | L-9 | 1899 | Bored, 2-inch | 63 | 63 | 80 | 29 | do | | | Stock | Small. |
| 1830 | do | do | L-9 | 1894 | do | 65 | 65 | 100? | 26 | do | | | Irrigation | Small. |
| 1831 | Mrs. Law | do | L-9 | 1885? | Bored, 4-inch | 61 | 60 | | 25 | Hand | | | Domestic | |
| 1832 | James Wilson | do | L-9 | 1898 | Bored, 2-inch | 62 | 62 | 362 | 46 | Artesian | 150.00 | | Domestic; irrigation. | Small. |
| 1833 | Carmenita School | do | L-9 | 1895 | do | 67 | 67 | 365 | 48 | do | 165.00 | | Domestic | Small. |
| 1834 | H. H. Hungerford | do | L-9 | 1891 | Bored, 4-inch | 67 | 67 | 104 | 29 | Hand | 78.00 | | do | |
| 1835 | John Aten | do | L-9 | 1899 | Bored, 2-inch | 65 | 65 | 300? | 25 | do | 100.00 | | Domestic; irrigation. | |
| 1836 | Mr. Branscom | do | L-9 | | Bored, 3-inch | 64 | 64 | | 24 | do | | | Irrigation | Small. |
| 1837 | do | do | L-9 | | Bored, 2-inch | 64 | 64 | | | Artesian | | | do | |
| 1838 | S. E. Samuel | do | L-8 | 1900 | Bored, 3-inch | 69 | 69 | 580 | 24 | do | 260.00 + | | do | |
| 1839 | do | do | L-8 | 1895 | Bored, 2-inch | 70 | 70 | 200 | 40 | Hand | 140.00 | | Domestic | |
| 1840 | J. R. Mitchell | do | L-9 | 1897 | do | 65 | 65 | 265 | 47 | Artesian | | | Domestic; irrigation. | Small. |
| 1841 | B. L. Hutchins | do | L-9 | 1897 | Bored, 3-inch | 61 | 61 | 400 | 31 | do | | | do | Small. |
| 1842 | do | do | L-9 | 1889 | Bored, 7-inch | | | 80 | | do | | | Stock | Small. |
| 1843 | J. R. Morrell | do | L-9 | 1896 | Bored, 2-inch | 61 | 61 | 344 | 53 | do | 100.00— | | Domestic; stock. | Small. |
| 1845 | Wm. Marriott | Los Cerritos | F-10 | 1899 | do | 57 | 57 | 661 | 32 | do | 200.00 | | Domestic; irrigation. | 2 |
| 1846 | L. B. Bronson | do | F-10 | 1903 | Bored, 4-inch | 57 | 57 | 111 | 23 | do | 100.00 | | Domestic | Small. |
| 1847 | W. Willard | do | E-10 | 1903 | Bored, 7-inch | 59 | 56 | 100 | 23 | Not installed | 50.00 | | Not used | |
| 1848 | do | do | E-10 | 1903 | Bored, 4-inch | 50 | 56 | 77 | | | 65.45 | | do | |
| 1849 | do | do | E, F-10 | 1903 | Bored, 2-inch | 58 | 56 | 90 | 25 | Hand | | | Domestic | |
| 1850 | F. A. Bronson | do | F-10 | 1902 | do | 59 | 60 | 135 | 23 | Gas, artesian | *500.00 | | Irrigation | |
| 1851 | do | do | F-10 | 1897 | do | 59 | 59 | 341 | 28 | Artesian | 110.00 | | Domestic; irrigation. | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1852 | J. B. Bean | Los Coyotes | E-10 | 1888? | Bored, 4-inch | 60 | 60 | 640 | | Artesian | | | Domestic | Small. |
| 1853 | H. W. McKelry | do | E-9 | | Bored, 2-inch | 60 | 60 | 400 | 24 | do | | | do | |
| 1854 | do | do | F-9, 10 | | do | 60 | 60 | 400 | 27 | do | | | Stock | 4 |
| 1855 | Mrs. Hale | do | E-9 | | do | 60 | 60 | | 29 | do | | | Domestic | Small. |
| 1856 | Ed. German | do | E-9 | | do | 61 | 61 | 400? | 29 | do | | | do | |
| 1857 | do | do | E-9 | | Bored, 5-inch | 61 | 61 | 400? | | do | | | Irrigation | Small. |
| 1858 | do | do | E-9 | | Bored, 2-inch | 61 | 61 | 400 | 27 | do | | | do | 4 |
| 1859 | Frank Mott | do | F-9 | 1899 | do | 61 | 61 | 350 | 28 | do | | | Domestic; irrigation. | |
| 1860 | do | do | F-9 | 1899 | do | 61 | 61 | 350 | 27 | do | | | Irrigation | |
| 1861 | A. A. Lewis | do | F-9 | 1897 | do | 61 | 61 | 528 | 27 | do | | | Domestic | |
| 1862 | do | do | F-9 | 1897 | do | 61 | 61 | 525 | 28 | do | | | Stock | Small. |
| 1863 | do | do | F-9 | 1897 | do | 61 | 61 | 525 | 25 | do | | | Stock; irrigation | |
| 1864 | do | do | F-9 | 1899 | do | 61 | 61 | 525 | 28 | do | | | do | 3 |
| 1865 | J. D. Fredericks | do | F-9 | 1897 | do | 61 | 61 | 150 | 26 | Wind | $75.00 | | Domestic | |
| 1866 | do | do | F-9 | 1897 | do | 61 | 61 | 150 | 25 | Artesian | | | Stock | Small. |
| 1867 | E. F. Gaines | do | F-9 | 1900 | do | 61 | 61 | 250 | 25 | do | 150.00 | | Domestic; stock | |
| 1868 | do | do | F-9 | 1900 | do | 61 | 61 | 250 | 24 | do | 150.00 | | Domestic | |
| 1869 | do | do | F-9 | 1900 | do | 61 | 61 | 250 | 23 | do | 150.00 | | Irrigation | 2 |
| 1870 | J. A. Wooley | do | F-9 | 1898 | Bored, 2½-inch | 61 | 61 | 240 | 25 | Artesian, wind | 60.00 | | Domestic | |
| 1871 | do | do | F-9 | 1898 | Bored, 2-inch | 61 | 61 | 500 | 29 | Artesian | | | Not used | †5 |
| 1872 | W. F. Harding | do | F-9 | 1901? | do | 60 | 60 | 250? | 25 | do | | | Domestic; irrigation. | Small. |
| 1873 | Mrs. Sweeney | do | F-9 | 1899? | do | 57 | 57 | 64 | 25 | do | 25.00 | | Stock | Small. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1874 | L. S. Kirkpatrick | do | F-9 | 1900 | do | 57 | 57 | 64 | 24 | Wind | 25.00 | | Domestic; stock | |
| 1875 | J. R. & W. A. Clark | do | F-9 | 1902 | Bored, 10-inch | 62 | 62 | 645 | 24 | Artesian | 1,300.50 | | Irrigation | 65 |
| 1876 | do | do | F-9 | 1897 | Bored, 7-inch | 62 | 62 | 645 | 24 | do | | | Stock; irrigation | 19 |
| 1877 | do | do | G-10 | 1901 | Bored, 12-inch | 61 | 61 | 802 | 24 | do | 1,500.00+ | | Irrigation | 27 |
| 1878 | do | do | G-10 | 1895 | Bored, 2-inch | 61 | 61 | 640 | 24 | do | | | Domestic | |
| 1879 | do | do | G-8 | 1890? | Bored, 7-inch | 61 | 61 | 250? | 24 | do | | | Stock | Small. |
| 1880 | do | do | G-10 | 1890 | do | 61 | 61 | 250? | | do | | | do | Small. |
| 1881 | do | do | G-10 | 1899 | Bored, 10-inch | 57 | 57 | 645 | 24 | do | | | Irrigation | 6 |
| 1882 | do | do | G-10 | 1896 | Bored, 2-inch | 56 | 56 | 250 | 25 | do | | | Domestic | Small. |
| 1883 | do | do | G-10 | 1894 | do | 52 | 52 | 250 | 24 | do | 62.50 | | do | Small. |
| 1884 | R. T. Neeley | do | G-9 | | do | 62 | 62 | | 25 | do | | | do | |
| 1885 | R. L. Andrews | do | G-9 | 1899 | do | 62 | 62 | 147 | 24 | Wind, artesian. | 50.00 | | do | 2 |
| 1886 | John Gessford | do | G-9 | 1898 | Bored, 4-inch | 63 | 63 | 450? | 25 | Artesian | | | do | Small. |
| 1887 | do | do | G-9 | 1901 | Bored, 12-inch | 64 | 64 | 450 | | Gas | 1,000.00 | $500.00 | Irrigation | 75 |
| 1888 | Jothan Bixby | do | G-9 | 1894 | Bored, 4-inch | 61 | 61 | 150 | 25 | Artesian, hand | | | Domestic | Small. |
| 1889 | do | do | G-9 | 1898 | Bored, 10-inch | 60 | 60 | 640 | 25 | Artesian | 1,500.00 | | Irrigation | 39 |
| 1890 | do | do | G-9 | 1896 | Bored, 7-inch | 61 | 61 | 680 | 25 | do | 1,500.00 | | do | 42 |
| 1891 | do | do | H-8 | 1900 | Bored, 10-inch | 70 | 70 | 680 | 25 | do | 1,500.00 | | do | 18 |
| 1892 | do | do | G-9 | 1897 | Bored, 2-inch | 61 | 61 | 600 | 24 | do | | | Domestic | |
| 1893 | do | do | H-8 | 1895 | do | 66 | 66 | 150? | 26 | do | | | Stock | Small. |
| 1894 | do | do | H-8 | | Bored, 7-inch | 62 | 62 | 150 | 34 | do | | | Domestic | Small. |
| 1895 | J. W. Furnivall | do | H-8 | 1900 | Bored, 2-inch | 67 | 67 | 165 | 27 | do | 65.00 | | do | Small. |
| 1896 | T. Gregory | do | G-9 | 1873? | Bored, 7-inch | 65 | 65 | 140 | 25 | do | | | do | |
| 1897 | do | do | G-9 | 1900 | Bored, 2-inch | 65 | 65 | 150 | 25 | do | 60.00 | | Domestic; stock | |
| 1898 | W. A. Reeves | do | G-9 | 1899 | do | 66 | 66 | 135 | 24 | do | 40.50 | | Domestic | |
| 1899 | Mrs. Mary Dougherty | do | G-9 | 1899 | do | 67 | 67 | 160? | 24 | do | | | do | |
| 1900 | A. Meissen | do | G-8 | 1903 | do | 71 | 71 | 146 | 23 | do | 65.70 | | Stock | 4 |
| 1901 | D. Henderson | do | G-8 | 1899 | do | 71 | 71 | 140 | 25 | do | 50.00 | | do | Small. |
| 1902 | W. Walton | do | G-8 | 1893 | Bored, 7-inch | 70 | 70 | 160 | 25 | do | | | Not used | |
| 1903 | do | do | G-8 | 1896 | Bored, 2-inch | 71 | 71 | 140 | | do | | | do | |
| 1904 | do | do | G-8 | 1896 | do | 71 | 71 | 150 | | do | | | do | |
| 1905 | D. Henderson | do | G-8 | 1891 | Bored, 7-inch | 70 | 70 | 170 | 25 | Artesian, wind | 255.00 | | Domestic; stock | Small. |
| 1906 | do | do | G-8 | 1896 | Bored, 2-inch | 69 | 69 | 209 | 25 | Artesian | 80.00 | | Stock | Small. |
| 1907 | Mrs. Peterson | do | G-8 | | do | 73 | 73 | 140 | 26 | do | | | do | 2 |
| 1908 | Mr. Sharpe | do | G-8 | | do | 75 | 75 | | 24 | do | | | do | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1909 | Mr. Wright | Los Cerritos | G-8 | 1900 | Bored, 2-inch | 72 | 72 | 150 | 24 | Artesian | | | Stock | Small. |
| 1910 | T. Gregory | do | G-9 | 1894 | do | 69 | 69 | 140 | 24 | do | $50.00 | | Domestic; stock. | Small. |
| 1911 | do | do | G-9 | 1897 | do | 69 | 69 | 625 | | do | 200.00 | | Not used | |
| 1912 | do | do | G-9 | 1897 | do | 69 | 69 | 625 | | do | 200.00 | | do | |
| 1913 | W. D. Thorn | do | F-9 | 1896 | do | 69 | 69 | 150 | | do | | | Stock | Small. |
| 1914 | John Newton | do | G-8 | 1899 | do | 71 | 71 | 130 | | do | | | Domestic; irrigation. | 3 |
| 1915 | A. Meissen | do | F-8 | 1899 | do | 71 | 71 | 118 | | do | 58.00 | | Domestic; stock. | 3 |
| 1916 | do | do | F-8 | 1900 | do | 71 | 71 | 165 | 25 | do | 66.00 | | Domestic | |
| 1917 | do | do | F-8 | 1902 | Bored, 7-inch | 72 | 72 | 128 | | do | 128.00 | | Irrigation | |
| 1918 | Mr. Sudor | do | G-8 | 1900 | Bored, 2-inch | 72 | 72 | 135 | 25 | do | 54.00 | | Stock | 2 |
| 1919 | Doctor McBurney | do | G-8 | 1899 | do | 72 | 72 | 140 | 25 | do | | | do | 2 |
| 1920 | do | do | G-8 | 1899 | do | 73 | 73 | | 25 | do | | | do | Small. |
| 1921 | T. Gregory | do | F-8 | 1898 | do | | | 140 | | do | 56.00 | | do | Small. |
| 1922 | Mrs. L. H. Germain | do | F-8 | 1899 | do | 73 | 73 | 144 | 25 | do | | | do | 2 |
| 1923 | do | do | F-8 | 1898 | do | 73 | 73 | 149 | 25 | do | 59.60 | | do | |
| 1924 | do | do | F-8 | 1898 | do | 73 | 73 | 152 | | Gas, artesian | 60.80 | | Domestic | 2 |
| 1925 | Mrs. Stella Meissein | do | G-8 | | do | 74 | 74 | | 25 | Artesian | | | Not used | |
| 1926 | E. A. Keller | do | F-8 | 1895 | do | 75 | 75 | 177 | 24 | Artesian, hand | 80.00 | | Domestic | |
| 1927 | Miss O'Connor | do | F-8 | 1898 | do | 76 | 76 | 250 | 23 | do | 80.00 | | Irrigation | Small. |
| 1928 | Mr. Peterson? | do | G-8 | | do | 76 | 76 | | 24 | do | | | Stock | Small. |
| 1929 | P. P. Donlay | do | G-8 | 1887? | do | 78 | 78 | 160 | | Hand | | | Domestic | |
| 1930 | do | do | G-8 | | Bored, 7-inch | 79 | 79 | 160 | | do | | | do | |
| 1931 | T. F. Downs | do | F-8 | 1902 | Bored 2-inch | 78 | 78 | 150? | 22 | Wind | 136.75 | $228.00 | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1932 | .....do..... | .....do..... | F-8..... | 1901 | .....do..... | 78 | 78 | ..... | 24 | Artesian..... | 84.45 | ..... | Stock..... | Small. |
| 1935 | J. S. Davee..... | Los Coyotes..... | J-8..... | 1903 | Dug, 3½ by 3½ foot. | 73 | 66 | 9 | 63 | Hand..... | ..... | ..... | .....do..... | ..... |
| 1936 | C. Nottingham..... | .....do..... | J-8..... | 1903 | Hydraulic, 2-inch. | 72 | 72 | 100 | 37 | Artesian..... | 50.00 | ..... | .....do..... | 3 |
| 1937 | M. Sproul..... | .....do..... | J-7..... | 1898 | Bored, 2-inch..... | 92 | ..... | 98 | 48 | Wind..... | ..... | ..... | Domestic; stock. | 1 |
| 1938 | M. T. Wright..... | .....do..... | J-8..... | ..... | .....do..... | 90 | 90 | 650? | 23 | Artesian..... | ..... | ..... | Domestic..... | Small. |
| 1939 | .....do..... | .....do..... | J-8..... | 1895? | Bored, 14-inch.... | 89 | 89 | 903 | .... | .....do..... | ..... | ..... | Irrigation..... | 16 |
| 1940 | D. D. Johnston..... | .....do..... | K-7..... | 1900 | Bored, 10-inch.... | 88 | 88 | 760 | 27 | .....do..... | 2,500.00 | ..... | .....do..... | 3 |
| 1941 | .....do..... | .....do..... | K-8..... | 1877 | Bored, 7-inch..... | 87 | 87 | 620 | 23 | Wind..... | 1,200.00 | 50.00 | Domestic..... | ..... |
| 1942 | S. J. Wicks..... | .....do..... | K-7, 8... | 1898 | Bored, 2-inch..... | 86 | 86 | 320 | 24 | Artesian..... | 80.00 | ..... | .....do..... | 1 |
| 1943 | Mrs. Holmes..... | .....do..... | K-8..... | 1898 | Hydraulic, 2-inch. | 81 | 81 | 511 | 24 | .....do..... | 125.00 | ..... | .....do..... | Small. |
| 1944 | John Dolland..... | .....do..... | K-8..... | 1893 | Bored, 7-inch..... | 82 | 82 | 550 | 25 | .....do..... | 1,000.00 | ..... | Stock..... | 106 |
| 1945 | .....do..... | .....do..... | K-8..... | 1893 | Bored, 2-inch..... | 82 | 82 | 500 | 24 | .....do..... | 300.00 | ..... | ..... | 1 |
| 1946 | .....do..... | .....do..... | J-8..... | 1898 | .....do..... | 80 | 80 | 150 | .... | .....do..... | 125.00 | ..... | Stock..... | ..... |
| 1947 | T. S. Dunn..... | .....do..... | K-7..... | 1890 | .....do..... | 91 | 91 | 450 | 26 | .....do..... | 100.00 | ..... | Domestic..... | Small. |
| 1948 | R. Phillips..... | .....do..... | K-7..... | 1883 | Bored, 4-inch..... | 94 | 82 | 100 | 45 | Gas..... | ..... | 287.00 | .....do..... | ..... |
| 1949 | M. A. Pendleton..... | .....do..... | K-7..... | 1883 | .....do..... | 95 | 70 | 100 | 75 | Wind..... | ..... | ..... | .....do..... | ..... |
| 1950 | .....do..... | .....do..... | K-7..... | 1902 | Bored, 7-inch..... | 95 | ..... | 100 | 30 | Hand..... | ..... | ..... | Stock..... | ..... |
| 1951 | M. Sproul..... | .....do..... | K-7..... | 1888 | Hydraulic, 2-inch. | 87 | 87 | 120 | 25 | Artesian..... | 60.00 | ..... | .....do..... | Small. |
| 1952 | M. Coulon..... | .....do..... | K-8..... | 1895 | Bored, 2-inch..... | 78 | 78 | 370 | 23 | .....do..... | 170.00 | ..... | Domestic..... | †1 |
| 1953 | Mr. Hunt..... | .....do..... | K-8..... | 1883 | Bored, 7-inch..... | 77 | ..... | 120 | 32 | Wind..... | 500.00 | 50.00 | .....do..... | ..... |
| 1954 | .....do..... | .....do..... | K-8..... | 1883 | .....do..... | 78 | 78 | 120 | .... | Artesian..... | 500.00 | ..... | Stock..... | Small. |
| 1955 | Edwin Cawston..... | .....do..... | K-8..... | 1896? | Bored, 2-inch..... | 76 | 76 | 498 | 23 | .....do..... | ..... | ..... | Domestic..... | ..... |
| 1956 | .....do..... | .....do..... | K-8..... | 1896 | .....do..... | 76 | 76 | 320 | 22 | .....do..... | ..... | ..... | Stock..... | ..... |
| 1957 | E. A. Venable..... | .....do..... | K-7..... | 1896 | .....do..... | 70 | 70 | 550 | 23 | .....do..... | ..... | ..... | Domestic; stock. | 2 |
| 1958 | .....do..... | .....do..... | L-8..... | 1896 | Bored, 7-inch..... | 72 | 72 | 100 | 32 | Hand..... | ..... | ..... | Domestic..... | ..... |
| 1959 | B. Branscon..... | .....do..... | L-8..... | 1897 | Hydraulic, 2-inch. | 73 | 73 | 500 | 25 | Artesian..... | 185.00 | ..... | Irrigation..... | 5 |
| 1960 | J. M. Frazer..... | .....do..... | L-8..... | 1900 | Bored, 2-inch..... | 77 | 77 | 565 | .... | .....do..... | 250.00 | ..... | .....do..... | 1¾ |
| 1961 | .....do..... | .....do..... | L-8..... | 1902 | .....do..... | 76 | 76 | 555 | 24 | .....do..... | 180.00 | ..... | Domestic; irrigation. | †2 |
| 1962 | C. H. Mettler..... | .....do..... | L-8..... | 1887 | Bored, 7-inch..... | 77 | 72 | 80 | 37 | Wind..... | ..... | ..... | Domestic..... | ..... |
| 1963 | A. T. Wilkinson..... | .....do..... | L-8..... | ..... | Bored, 2-inch..... | 75 | ..... | 90 | 38 | .....do..... | ..... | ..... | .....do..... | ..... |
| 1964 | Will Clanton..... | .....do..... | L-8..... | ..... | Driven, 4-inch.... | 77 | ..... | 60 | 37 | Hand..... | ..... | ..... | .....do..... | ..... |
| 1965 | W. A. Thompson..... | .....do..... | L-8..... | 1883 | Bored, 7-inch..... | 78 | 78 | 393 | 24 | Artesian..... | ..... | ..... | Domestic; stock. | Small. |
| 1966 | .....do..... | .....do..... | K-8..... | 1898 | Bored, 2-inch..... | 80 | 80 | 500 | 29 | .....do..... | 200.00 | ..... | Stock..... | Small. |
| 1967 | Wm. Newton..... | .....do..... | L-8..... | 1890 | .....do..... | 83 | 83 | 717 | 28 | .....do..... | 186.00 | ..... | Irrigation..... | 7 |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 1968 | Wm. Newton | Los Coyotes | L-8 | 1891 | Bored, 2-inch | 83 | 83 | 724 | 24 | Artesian | $253.00 | | Domestic; irrigation. | 1¾ |
| 1969 | J. M. Frazer | do | L-8 | | do | 81 | 81 | 830 | 31 | do | | | Stock | 1 |
| 1970 | do | do | L-8 | | Bored, 3-inch | 81 | 81 | 550 | 40 | do | | | do | Small. |
| 1971 | E. Thowson | do | L-7 | | Bored, 4-inch | 85 | 78 | 57 | 32 | Hand | | | do | |
| 1972 | John Baker | do | L-7 | 1898 | Bored, 2-inch | 87 | | 115? | 39 | do | | | Domestic | |
| 1973 | J. Hualde | do | K, L-7 | 1891 | Bored, 7-inch | 92 | 92 | 114 | | Wind | 120.00 | | Domestic; stock | |
| 1974 | J. W. Inman | do | K-7 | 1891 | do | 91 | 86 | 104 | 38 | do | 117.00 | $30.00 | Stock; irrigation | |
| 1975 | do | do | K-7 | 1897 | Bored, 2-inch | 95 | 95 | 675 | | Artesian | 200.00 | | do | |
| 1976 | John Baker | do | K-7 | 1897 | do | 88 | 86 | 70 | 45 | Wind | 25.00 | 30.00 | Stock | |
| 1977 | A. W. Surbeck | do | K-7 | 1890 | Bored, 7-inch | 88 | 82 | 84 | 57 | do | 85.00 | 350.00 | Domestic | |
| 1978 | do | do | K-7 | 1897 | Bored, 2-inch | 85 | 83 | 80 | 49 | Hand | 40.00 | 10.00 | Stock | |
| 1979 | D. Mabry | do | K-7 | 1895? | do | 89 | | 90 | 55 | do | 45.00 | | Domestic | |
| 1980 | L. M. McConnell | do | K-8 | 1895 | do | 79 | | 92 | 47 | do | 45.00 | | do | |
| 1981 | Geo. W. Wardell | do | K-8 | 1902 | do | 79 | 79 | 476 | 25 | Artesian | 190.00 | | Irrigation | 1 |
| 1982 | do | do | K-8 | 1900 | do | 79 | 75 | 76 | 37 | Hand | 37.50 | | Domestic | |
| 1983 | S. Wardell | do | L-8 | | do | 79 | 79 | 650 | 26 | Artesian | | | Stock | 1½ |
| 1984 | W. H. Miller | do | K-8 | 1903 | do | 80 | | 89 | | Gas | 230.00 | | Irrigation | |
| 1985 | H. E. Belfield | do | L-8 | 1899 | do | 73 | 73 | 565 | 25 | Artesian | 200.00 | | Domestic | 2 |
| 1986 | do | do | L-8 | 1896 | do | 72 | 72 | 300 | 25 | do | 175.00 | | do | 1½ |
| 1987 | do | do | L-8 | | Bored, 4-inch | 71 | | 75 | 37 | Wind | | | do | |
| 1988 | W. Hungerford | do | L-8, 9 | 1873? | Bored, 7-inch | 70 | 70 | 400 | 32 | Artesian | | | Domestic; stock. | 1 |
| 1989 | J. R. Mitchell | do | L-8 | 1878 | do | 69 | 68 | 180 | 31 | Hand | | | Stock | |
| 1990 | do | do | L-8, 9 | 1900 | Bored, 3-inch | 67 | 67 | 600 | | Artesian | 275.00 | | Irrigation | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1991 | A. T. Wilkinson | do | L. 8 | 1901 | Bored, 2-inch | 75 | 75 | 230 | | do | 125.00 | | do | | †1 |
| 1992 | J. N. Smith | do | L. 8 | 1881 | Bored, 7-inch | 74 | 73 | 283 | 29 | Hand | 500.00 | | Domestic | | |
| 1993 | do | do | L. 8 | 1886? | do | 73 | 69 | 163 | | do | 150.00 | | Not used | | |
| 1994 | W. P. Eshon | do | M-8 | 1901 | Bored, 2-inch | 72 | 72 | 73 | | Artesian | 35.10 | | Domestic; stock. | Small. | |
| 1995 | Wm. Newton | do | M-8 | | do | 65 | 65 | 570 | 47 | do | | | Stock; irrigation | †1 | |
| 1996 | J. F. Overton | do | N-10 | 1901 | Bored, 3-inch | 64 | 64 | 280 | 51 | do | | | Domestic; irrigation. | 4 | |
| 1997 | do | do | N-10 | 1885? | do | 65 | 65 | 230 | 35 | Artesian, wind | | | do | | |
| 1998 | J. F. Hamm | do | N-10 | 1897? | do | 66 | 65 | 90 | 39 | Artesian | 40.00 | | Domestic | | |
| 1999 | C. F. Robinson | do | N-10 | 1896 | do | 70 | 70 | 167 | 38 | do | | | Domestic; stock. | Small. | |
| 2000 | A. C. Mann | do | N-10 | 1901 | Bored, 2-inch | 65 | 65 | 75 | 37 | do | 40.00 | | Domestic | Small. | |
| 2001 | John Kellenberger | do | N-10 | 1898 | Bored, 3-inch | 64 | 64 | 220 | 38 | do | 90.00 | | Stock; domestic. | Small. | |
| 2002 | U. S. Scales | do | N-10 | 1893? | Bored, 2-inch | 62 | 62 | 450 | 38 | do | | | Domestic; irrigation. | Small. | |
| 2003 | W. A. Tracy | do | N-10 | 1898 | Hydraulic, 4-inch. | 70 | 70 | 265 | | do | 210.00 | | do | | |
| 2004 | M. Raymond | do | N-10 | 1896? | Bored, 4-inch | 69 | 69 | 190 | 35 | Artesian, hand | | | do | Small. | |
| 2005 | H. G. Bixby | do | N-10 | 1898? | Bored, 3-inch | 73 | 73 | 190 | 38 | Wind | | | Domestic | Small. | |
| 2006 | S. R. Brewer | do | N-10 | 1898 | Bored, 2-inch | 74 | 74 | 190 | 36 | do | 70.00 | 140.00 | do | | |
| 2007 | J. H. Whitaker | do | N-10 | 1897 | do | 75 | 75 | 200 | 35 | Artesian, wind | 75.00 | 142.50 | do | Small. | |
| 2008 | N. V. Brown | do | N-10 | 1901 | do | 74 | 74 | 199 | 33 | Wind | 80.00 | 100.00 | do | | |
| 2009 | D. W. Hasson | do | N-10 | 1898 | Bored, 3-inch | 73 | 73 | 268 | 37 | Artesian | 150.00 | | Domestic; irrigation. | | |
| 2010 | John Cowan | do | N-10 | 1894? | Bored, 6-inch | 71 | 71 | 250 | 36 | do | 250.00 | | Domestic | | |
| 2011 | do | do | N 10 | 1897 | do | 70 | 70 | 250 | 33 | do | 250.00 | | Stock | | |
| 2012 | J. Porte | do | N-9 | | Bored, 2-inch | 70 | 65 | 200 | 39 | Hand | | | Domestic | | |
| 2013 | C. J. Deoodeon | do | N 9 | 1894 | Bored, 7-inch | 66 | 66 | 420 | 59 | Artesian | 300.00 | | Irrigation | | |
| 2014 | do | do | N-9 | 1897 | Bored, 10-inch | 67 | 67 | 425 | | do | 400.00 | | Stock | | |
| 2015 | do | do | N-9 | 1893? | Dug, 3 by 3 foot | 68 | 65 | 5 | 35 | Hand | | | do | | |
| 2016 | C. L. McComber | do | N-8 | 1898 | Bored, 7-inch | 105 | 101 | 450 | 32 | Wind | | 160.00 | Domestic | | |
| 2018 | Geo. B. Reebe | do | N-8 | 1898 | Bored, 10-inch | 136 | 96 | 450 | 43 | | 1,439.00 | 1,500.00 | Irrigation | 10 | |
| 2019 | do | do | N-8 | 1896 | Bored, 10-inch, 600 feet; 8-inch, 50 feet; 6-inch, 250 feet. | 125 | 75 | 900 | 31 | Gas | 4,140.50 | | do | 15 | |
| 2020 | do | do | N-8 | 1902 | Bored, 10-inch | 213 | 213 | 1,360 | 55 | Artesian | 8,280.00 | | do | 2 | |
| 2021 | E. D. Wood | do | N-8 | 1903 | Dug, 4 by 4 foot | 78 | 59 | 22 | 72 | Wind | | | Domestic | | |
| 2022 | do | do | M-8 | 1902 | Dug, 3½ by 3½ foot. | 73 | 69 | 8 | | Hand | | | Stock | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2023 | S. Forbes | Los Coyotes | M-8 | 1898? | Bored, 2-inch | 72 | 72 | 600 | 31 | Artesian | | | Domestic; irrigation. | 1 |
| 2024 | J. W. Brown | do | M-8 | 1899 | do | 73 | 71 | 90 | 45 | Hand | $21.00 | | Domestic | |
| 2025 | B. W. Hutchinson | do | M-8 | 1897 | do | 73 | 63 | 92 | 36 | do | 90.00 | | do | |
| 2026 | do | do | M-8 | 1899 | Hydraulic, 2-inch | 74 | 74 | 526 | | Artesian | 225.00 | | Irrigation; stock | 6 |
| 2027 | J. W. Brown | do | M-8 | 1899 | Bored, 2-inch | 72 | 67 | 61 | 61 | Hand | 24.00 | | Stock | |
| 2028 | J. S. Copeland | do | M-7, 8 | | do | 95 | 95 | 600? | 44 | Artesian | | | Domestic | |
| 2029 | do | do | M-7 | 1894? | Bored, 10-inch | 93 | 93 | 750? | 43 | Gas | | | Stock | 10 |
| 2030 | Mr. McNally | do | M-8 | 1894 | Bored, 8-inch | 97 | 97 | 441 | 35 | Gas, artesian | 555.00+ | $1,300.00 | Irrigation; domestic. | 40 |
| 2031 | do | do | M-7 | 1894 | Bored, 7-inch | 133 | | 480 | | | 212.50+ | | | |
| 2032 | do | do | M-7 | | Bored, 8-inch | | | 500 | | Gas | | | Irrigation | |
| 2033 | do | do | N-6 | 1894? | Bored, 10-inch | | | 634 | | | | | Not used | |
| 2034 | do | do | M-7 | 1895 | do | 152 | 152 | 609 | | Gas, artesian | 1,200.00 | | Irrigation | Small. |
| 2035 | do | do | M-7 | 1900 | do | 135 | 135 | 680 | 98 | Artesian | | | do | †25 |
| 2036 | C. Underwood | do | M-6 | | Bored, 7-inch | 125 | 125 | 198 | | do | | | Domestic; stock | |
| 2037 | do | do | M-6, 7 | 1897 | do | 125 | 125 | 450 | 56 | do | 880.00 | | Domestic | |
| 2038 | Geo. B. Reebe | do | M-7 | 1895? | Bored, 2-inch | 100 | 100 | 500? | 45 | Hand | | | | |
| 2039 | do | do | L-6, 7 | 1900 | Bored, 3-inch | 80 | 80 | 815 | 85 | Artesian | | | Irrigation | |
| 2040 | do | do | L-6, 7 | 1900 | do | 80 | 80 | 818 | 78 | do | | | do | |
| 2041 | H. B. Hawk | do | M-7 | | Bored, 2-inch | 125 | 125 | 400? | | Wind | | | do | |
| 2042 | do | do | M-7 | 1894 | Bored, 7-inch | 125 | 108 | 415 | | do | 800.00 | | do | |
| 2043 | do | do | M-7 | | Bored, 10-inch | 105 | 104 | 400? | 36 | Gas | | 1,000.00 | Irrigation; domestic. | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2044 | John Vaughn | do | M-7 | | Bored, 2-inch | 85 | 85 | 580 | | Artesian | | | Stock | Small. |
| 2045 | do | do | L-7 | 1896 | do | 97 | 97 | 615 | 37 | Wind, artesian | 280.00 | 175.00 | Domestic | |
| 2046 | do | do | L-7 | 1896 | do | 98 | 98 | 620 | | Wind | 282.80 | 150.00 | Stock | |
| 2047 | do | do | L-6 | 1896 | do | 100 | 100 | 610 | 26 | Artesian | 278.00 | | do | †1 |
| 2048 | do | do | L-7 | 1897 | Bored, 12-inch | 90 | 90 | 144 | | Gas | 395.00 | 400.00 | | |
| 2049 | Benj. Branscom | do | L-7 | 1900 | Bored, 3-inch | 95 | 95 | 750 | 47 | Artesian | 425.00 | | Not used | |
| 2050 | do | do | L-7 | 1900 | Bored, 2-inch | 95 | 95 | 810 | 49 | do | 325.00 | | do | †1 |
| 2051 | Lee Seabridge | do | L-7 | 1901 | do | 87 | | 157 | 34 | Wind | | | Stock | |
| 2052 | J. B. Thornton | do | L-7 | 1899 | Bored, 3-inch | 85 | 85 | 678 | | Artesian | 250.00 | | Stock; irrigation | |
| 2053 | do | do | L-7 | 1895? | Bored, 2-inch | 86 | 86 | 490 | 34 | do | 135.00 | | Domestic; stock | Small. |
| 2054 | H. H. Venable | do | K-7 | 1897 | do | 97 | 97 | 513 | 25 | do | 190.00 | | Domestic | Small. |
| 2055 | W. W. Clanton | do | K-7 | 1889? | Bored, 4-inch | 99 | 88 | 80 | 55 | Wind | | 150.00 | do | |
| 2056 | J. M. Clanton | do | K-7 | 1888? | do | 98 | 86 | 404 | 43 | do | | 150.00 | do | |
| 2057 | J. W. Porter | do | K-7 | 1902 | Bored, 10-inch | 97 | 87 | 223 | 22 | Steam | 376.00 | 940.00 | Irrigation | 96 |
| 2058 | do | do | K-7 | 1895 | Bored, 2-inch | 97 | 95 | 425 | 21 | Wind | 215.00 | 150.00 | Domestic | |
| 2059 | John Venable | do | K-7 | 1891 | Dug, 4 by 4 foot | 100 | 91 | 12 | 77 | do | | | | |
| 2060 | J. N. Clanton | do | K-7 | 1898 | Bored, 3-inch | 107 | 95 | 62 | 54 | do | | 180.00 | Domestic | |
| 2061 | R. B. Venable | do | K-6 | 1896? | Bored, 2-inch | 115 | 107 | 130 | 49 | do | 50.00 | 75.00 | do | |
| 2062 | M. Meyer | Santa Gertrudis | K-6 | 1901 | Dug, 3½ by 3 foot | 125 | 105 | 22 | 91 | Hand | | | Stock | |
| 2063 | Mrs. S. Bland | Los Coyotes | L-6 | | Bored, 7-inch | 113 | 105 | 356 | 34 | Wind | | | Domestic | |
| 2064 | do | do | L-6 | 1902 | Bored, 12-inch 5-inch. | 113 | 113 | 735 | 78 | Artesian | | | Irrigation | 8 |
| 2065 | W. H. Harp | do | L-6 | 1897 | Bored, 8-inch | 125 | 109 | 568 | 57 | Wind | 950.00 | 150.00 | Domestic; irrigation. | |
| 2066 | do | do | L-6 | 1899 | Hydraulic, 3-inch | 125 | 125 | 703 | | Artesian | 350.00 | | Stock; irrigation | †3 |
| 2067 | M. Meyer | Santa Gertrudis | L-5 | 1902 | Bored, 7-inch | 175 | 159 | 125 | 75 | Wind | 120.00 | 125.00 | Domestic | |
| 2068 | John S. Baker | do | K-5 | 1887 | do | 162 | 128 | 110 | 51 | do | 125.00 | 180.00 | do | |
| 2069 | do | do | K-5 | 1901 | Bored, 10-inch | 175 | 152 | 398 | | | 2,023.00 | | Not used | |
| 2070 | do | do | K-5 | 1901 | Bored, 8-inch | 175 | 152 | 435 | | | | | | |
| 2071 | do | do | K-5 | 1897 | Bored, 7-inch | 155 | 119 | 52 | 56 | Wind | | 125.00 | Domestic | |
| 2072 | Los Angeles National Bank. | do | K, L-5 | 1894? | Bored, 4-inch | 168 | 134 | 60 | 47 | Gas | | | Domestic; irrigation. | |
| 2073 | C. H. Benton | do | L-5 | 1892 | do | 170 | 135 | 70 | 51 | Wind | 56.00 | 300.00 | Domestic | |
| 2074 | do | do | L-5 | 1899 | Hydraulic, 2-inch | 170 | | 804 | | | | | | |
| 2075 | Mrs. W. A. Gunn | do | L-5 | 1878? | Bored, 5½-inch | 165 | 138 | 300 | 57 | Gas | | 450.00 | Domestic | |
| 2076 | do | do | L-5 | 1891 | Bored, 4-inch | 163 | 133 | 120 | | Hand | | | Stock | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2077 | E. Wickman | Santa Gertrudis | K-5 | 1898 | Dug, 3 by 4 foot | | | 35 | | Wind | | | Domestic | |
| 2078 | Railroad station | do | K-5 | 1897 | Bored, 4-inch | 158 | 128 | 80 | 27 | Hand | $70.00 | | | |
| 2079 | W. B. Ellis | do | K-5 | 1900 | Driven, 3½-inch | 164 | 130 | 37 | 47 | do | 45.00 | | Domestic; stock | |
| 2080 | Mr. Hollenbeck | do | K-4 | 1900 | Dug, 4-foot diameter. | 162 | 130 | 35 | 63 | Wind | 50.00 | $125.00 | Domestic | |
| 2081 | C. H. Girdlestone, agent | do | K-5 | | Bored, 7-inch | 157 | 127 | 190 | 29 | do | | | do | |
| 2082 | Frank Groves | do | K-5 | | Dug, 4 by 4 foot | 159 | 134 | 28 | | Hand | | | | |
| 2083 | C. H. Girdlestone, agent | do | K-5 | 1874 | Bored, 7-inch | 159 | | 300 | 75 | do | | | Domestic | |
| 2084 | do | do | K-5 | | do | 159 | 142 | 300 | 81 | Wind | | | do | |
| 2085 | J. W. Weaver | do | J, K-4 | 1992 | Dug, 3½-foot diameter. | 159 | 132 | 30 | 53 | Hand | 40.00 | | do | |
| 2086 | C. C. Mason | do | K-5 | 1888 | Bored, 7-inch | 159 | 134 | 52 | 80 | Wind | 105.00 | 110.00 | do | |
| 2087 | do | do | K-4 | 1888 | do | 159 | 134 | 85 | | do | 170.00 | 115.00 | Domestic; stock | |
| 2088 | Mrs. L. Hein | do | J-5 | 1903 | Dug, 2-foot diameter. | 155 | 128 | 30 | 66 | Hand | 52.50 | | Domestic | |
| 2089 | J. M. Ellis | do | K-5 | 1893 | Dug, 4-foot diameter. | 156 | 128 | 31 | 94 | do | 45.00 | | do | |
| 2090 | O. Blanchard | do | K-5 | | Dug, 2-foot diameter. | 168 | 136 | 36 | | Wind | 50.00 | | do | |
| 2091 | C. W. Duncan | do | K-5 | 1891 | Bored, 2-inch | 168 | 138 | 127 | 41 | do | 140.00 | | do | |
| 2092 | J. S. Buckbee | do | K-5 | 1899 | Dug, 3½ foot diameter. | 166 | 132 | 37 | 38 | do | 40.00 | 110.00 | do | |
| 2093 | John S. Baker | do | K-5 | | Bored, 7-inch | 150 | 118 | 108 | 39 | Hand | 125.00 | | do | |
| 2094 | C. Palm | do | K-5 | 1896 | Bored, 2-inch | 161 | 160 | 275 | 62 | do | | | do | |
| 2095 | P. Bedler | do | J-5 | 1895? | do | 140 | | 105 | 31 | do | 50.00 | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2006 | J. C. Clark | do | J-5 | | do | 142 | 140 | 185 | 51 | do | | | Stock | | |
| 2007 | do | do | J-5 | | Bored, 4-inch | 144 | | 60? | 52 | Wind | 55.00 | 150.00 | Domestic | | |
| 2008 | John Paddison | do | J-7 | | do | 152 | | 1102 | 34 | do | | | do | | |
| 2009 | J. W. Sharp | do | J-5 | 1877? | Bored, 7-inch | 150 | | 380 | | | | | Not used | | |
| 2100 | do | do | J-5 | 1877? | do | 145 | | 380 | 50 | Wind | | | Domestic | | |
| 2101 | do | do | J-5 | 1902 | Bored, 12-inch | 130 | | 94 | 39 | Gas? | | | | | |
| 2102 | do | do | J-5 | 1903 | do | 130 | | 94? | | do | | | | | |
| 2103 | J. S. Brown | do | J-5 | 1893? | Bored, 2-inch | 135 | | 385 | 60 | Wind | | | Domestic | | |
| 2104 | do | do | J-5 | | Bored, 7-inch | 133 | | 385? | | Hand | | | Not used | | |
| 2105 | J. H. Haddock | do | J-5 | 1902 | Bored, 4-inch | 140 | 129 | 117 | 38 | do | 102.00 | | Domestic | | |
| 2106 | A. Loveall | do | J-5 | 1901 | Bored, 5-inch | 130 | 118 | 66 | 44 | Wind | 55.00 | | do | | |
| 2107 | Fred Hum ler | do | J-5 | 1889 | Bored, 3-inch | 130 | 105 | 80 | 45 | do | | | do | | |
| 2108 | C. B. Woodhead | do | J-5 | 1880? | Bored, 7-inch | 127 | | | | | | | Not used | | |
| 2109 | do | do | J-5 | 1898? | Bored, 8-inch | 125 | | 702 | 62 | Artesian | | | Stock | 20 | |
| 2110 | do | do | J-5 | | Bored, 3-inch? | 133 | | | 37 | Wind | | | Domestic | | |
| 2111 | A. C. Ramirez | do | J-5 | | Bored, 4-inch | 144 | | 68 | 60 | do | | | do | | |
| 2112 | John W. Rannalls | do | K-6 | 1903 | Bored, 5-inch | 125 | 120 | 381 | | | 450.00 | | Not installed | | |
| 2113 | do | do | J-6 | 1893 | do | 116 | 76 | 50 | 65 | Hand | 50.00 | | Domestic | | |
| 2114 | Mr. Obair | do | J-6 | 1903 | Bored, 12-inch | 117 | 112 | 730 | 24 | Gas, wind | | 1,000.00 | Domestic; irrigation. | 80 | |
| 2115 | John Paddison | do | J-6 | 1902 | do | 117 | 110 | 250 | | Gas | 500.00 | 800.00 | Irrigation | †50 | |
| 2116 | do | do | J-6 | 1884 | Bored, 4-inch | 115 | 113 | 267 | 35 | Wind | | 130.00 | Domestic | | |
| 2117 | Norwalk Co. Creamery. | Los Coyotes | J-7 | | Bored, 2-inch | 112 | | 450 | 22 | Hand | | | do | | |
| 2118 | Mrs. A. M. Sproule | do | J-7 | 1900 | do | 102 | 87 | 150 | 34 | do | | | Stock | | |
| 2119 | J. S. Bland | do | J-7 | 1902 | do | 100 | | 100 | 50 | Wind | 52.00 | 88.00 | Domestic | | |
| 2120 | Mrs. A. M. Sproule | do | J-7 | 1899 | do | 101 | | 660 | | | 400.00 | | do | | |
| 2121 | F. Hawkins | do | J-7 | 1901 | Bored, 3-inch | 98 | | 110 | 39 | Wind | 60.00 | | do | | |
| 2122 | J. S. Elliot | do | J-7 | 1897 | Bored, 2-inch | 99 | 95 | 490 | 26 | do | 375.00 | | do | | |
| 2123 | E. Stiffler | do | J-7 | | Bored 4-inch | 99 | 89 | 100? | 61 | do | | | do | | |
| 2124 | Mrs. F. A. Haddock | do | J-7 | 1901 | do | 100 | 88 | 90 | 56 | do | 55.00 | 125.00 | do | | |
| 2125 | Norwalk Building Association. | do | J-7 | 1893 | Bored, 7-inch | 100 | 89 | 97 | 51 | do | 125.00 | 225.00 | do | | |
| 2126 | R. A. Byron | do | J-7 | 1900 | Bored, 8-inch | 100 | 89 | 104 | 53 | Gas | 110.00 | 375.00 | do | | |
| 2127 | J. Swagart | do | J-7 | 1886? | do | 100 | | 104 | 64 | Wind | | | do | | |
| 2128 | L. Langley | Santa Gertrudis | J-7 | 1891 | Bored, 2-inch | 103 | | 40 | 53 | Hand | | | do | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2129 | J. Watson | Santa Gertrudis | J-6 | | Bored, 2-inch | 108 | | 165 | 40 | Hand | | | Domestic | |
| 2130 | W. W. McElhiney | do | J-6 | 1882? | Bored, 4-inch | 109 | 101 | 312 | 25 | Wind | | | do | |
| 2131 | W. W. Orr | do | J-6 | 1883 | Bored, 7-inch | 118 | 109 | 50 | 46 | do | $52.00 | $100.00 | Stock | |
| 2132 | do | do | J-6 | 1898 | do | 117 | 107 | 50 | 62 | do | 50.00 | | Domestic | |
| 2133 | C. E O'Conner | do | J-6 | 1898 | Bored, 2-inch | 122 | | 72 | 91 | do | 23.00 | 270.00 | do | |
| 2134 | do | do | J-5 | 1900 | Bored, 12-inch | 122 | 114 | 109 | | | 170.00 | | Not used | |
| 2135 | J. D. Crawford | do | J-5 | 1885? | Bored, 4-inch | 128 | 116 | 62 | 102 | Wind | | | Domestic | |
| 2136 | S. J. Lovell | do | J-5 | 1899 | Dug, 4 by 4 foot | 124 | 117 | 10 | 96 | Hand | | | do | |
| 2137 | O. Newlan | do | I-5 | | Bored, 4-inch | 127 | | 35 | 80 | do | | | do | |
| 2138 | R. H. Haddock | do | I-5 | 1903 | Bored, 12-inch | 129 | 118 | 96 | 59 | Gas | 180.00 | 600.00 | Irrigation | |
| 2139 | D. E. Haddock | do | I-5 | 1883 | Bored, 2-inch | 131 | 118 | 57 | 61 | Hand | | | Domestic | |
| 2140 | J. F. Moore | do | I-5 | 1902 | Bored, 5-inch | 130 | 118 | 44 | 52 | do | 38.00 | | do | |
| 2141 | L. W. Houghton | do | I-4 | 1896 | Bored, 2-inch | 130 | 118 | 60 | 40 | do | | | do | |
| 2142 | do | do | I-4 | 1899 | Bored, 12-inch | 129 | | 50 | | Gas? | 75.00 | | Irrigation | |
| 2143 | do | do | I-4 | 1899 | Bored, 10-inch | 129 | 129 | 775 | 23 | Gas, artesian | 2,000.00 | 1,625.00 | do | |
| 2144 | W. W. Orr | do | J-4 | 1896 | Bored, 8-inch | 141 | 132 | 36 | 50 | Wind | 35.00 | 200.00 | Stock | |
| 2145 | Mrs. Carey | do | J-4 | | do | 141 | 131 | 44 | 51 | do | | | Domestic | |
| 2146 | L. W. Houghton | do | I, J-4 | | Dug, 4 by 4 foot | 133 | 121 | 16 | 32 | Hand | | | do | |
| 2147 | J. C. Dashiell | do | I-5 | 1896? | Bored, 2-inch | 122 | 112 | 51 | 55 | Wind | 50.00 | 200.00 | Stock; domestic | |
| 2148 | Mr. Schendoney | do | I-5 | 1903 | Bored, 3-inch | 120 | | 55 | 78 | do | | | Domestic | |
| 2149 | L. W. Houghton | do | L-5 | 1903 | Bored, 5-inch | 119 | 107 | 57 | 39 | Hand | 51.30 | | do | |
| 2150 | do | do | I-5 | 1900 | Driven, 4-inch | 116 | 104 | 34 | 40 | Wind | | 210.00 | do | |
| 2151 | Mr. Glasselle | do | I-5 | 1882 | Bored, 5-inch | 114 | 104 | 63 | 57 | do | | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2152 | L. W. Houghton | do | I-5 | 1900 | Bored, 4-inch | 116 | 104 | 54 | 57 | do | 40.00 | 150.00 | do | | |
| 2153 | B. M. Moore | do | I-5 | 1903 | do | 118 | 106 | 63 | 69 | do | 56.70 | | do | | |
| 2154 | Mrs. F. A. Haddock | do | I-5 | 1880? | Bored, 8-inch | 121 | 115 | 300? | 28 | do | | | do | | |
| 2155 | J. N. Newlan | do | I-5 | 188- | Bored, 4-inch | 120 | 110 | 45? | 75 | do | | 150.00 | do | | |
| 2156 | H. W Beest | do | J-5 | 188- | do | 122 | 111 | 50 | 42 | Hand | | | do | | |
| 2157 | J. N. Newlan | do | I-5 | 1880 | Bored, 2-inch | 117 | | 50 | | do | | | do | | |
| 2158 | do | do | I-6 | 1900 | Dug, 3 by 3 foot | 117 | 97 | 13 | | do | | | Stock | | |
| 2159 | Frank Irish | do | J-6 | 1892 | Bored, 8-inch | 107 | 99 | 64 | 54 | Wind | | | Domestic | | |
| 2160 | L. J. Bever | do | J-6 | 1902 | Bored, 5-inch | 105 | 97 | 50 | 73 | do | 42.50 | 150.00 | do | | |
| 2161 | R. W. Hill | do | I-6 | 1899 | Bored, 3-inch | 104 | 97 | 75 | 37 | Hand | | | Stock | | |
| 2162 | J. A. Worthen | do | I-6 | | Bored, 2-inch | 105 | 98 | 80? | 37 | Wind | | | Domestic | | |
| 2163 | W. W. Clemons | do | I-6 | 1890 | Bored, 4-inch | 102 | | 62 | 47 | do | | | do | | |
| 2164 | E. J. Hill | do | I-6 | 1888 | do | 102 | 98 | 62 | 50 | Hand | 40.00 | | do | | |
| 2165 | do | do | I-6 | 1902 | Bored, 12-inch | 102 | 98 | 87 | | Gas | 175.00 | 1,000.00 | Irrigation | 80 | |
| 2166 | Chas. Emery | do | I-6 | 1888 | Driven, 2-inch | 101 | | 26? | | Hand | | | Domestic | | |
| 2167 | Morton Bros. | do | I-6 | | do | 102 | | 30 | 45 | do | | | do | | |
| 2168 | J. K. Brenizer | do | I-5 | 1882 | Bored, 4-inch | 110 | 100 | 63 | 52 | do | 63.00 | | do | | |
| 2169 | do | do | I-5 | 1902 | Dug, 4 by 4 foot | 110 | 100 | 14 | 200+ | do | | | Stock | | |
| 2170 | Chas. Collins | do | I-6 | 1903 | Bored, 12-inch | 108 | 98 | 237 | 28 | Gas | 474.00 | 2,120.00 | Irrigation | †150 | |
| 2171 | do | do | I-6 | 1903 | do | 108 | 98 | 241 | | do | 482.00 | | do | | |
| 2172 | do | do | I-6 | 1879? | Bored, 7-inch | 106 | 95 | 125 | 40 | Wind | | | Domestic | | |
| 2173 | A. Pilkington | do | I-5,6 | 1900 | Bored, 4-inch | 108 | 98 | 70 | 50 | Hand | | | do | | |
| 2174 | H. D. Kinney | do | I-5 | 1889? | do | 108 | | 62 | 54 | do | | | do | | |
| 2175 | N. T. Cowan | do | I-6 | 1900 | do | 108 | | 64 | 47 | do | 32.00 | | do | | |
| 2176 | E. C. White | do | I-6 | 1895? | Bored, 2-inch | 107 | | 42? | 45 | do | | | do | | |
| 2177 | N. H. Hughes | do | I-6 | 1895 | Bored, 4-inch | 105 | 95 | 80 | 41 | do | 65.00 | | do | | |
| 2178 | M. Long | do | I-6 | | Driven, 2-inch | | | 20 | 56 | do | | | do | | |
| 2179 | do | do | I-6 | | Dug, 3 by 4 foot | | | 12 | 140 | do | | | Stock | | |
| 2180 | Geo. A. Smith | do | I-6 | 1902 | Bored, 2-inch | 105 | | 68 | 67 | do | | | do | | |
| 2181 | J. P. Green | do | I-6 | 1883 | Dug, 2 by 3 foot | 102 | 95 | 10 | 111 | Hand | | | Domestic | | |
| 2182 | do | do | I-6 | 1900 | do | 101 | 95 | 10 | 69 | do | | | Stock | | |
| 2183 | M. A. Murphy | do | I-6 | 1901 | Bored, 2-inch | 98 | | 60? | 47 | do | | | Domestic | | |
| 2184 | P. Benson | do | H-6 | | Bored, 4-inch | 97 | 93 | 79 | 48 | do | | | do | | |
| 2185 | G. M. Clark | do | I-6 | 1902 | Bored, 12-inch | 99 | 93 | 108 | | Gas | 200.00 | 1,000.00 | Irrigation | 130 | |
| 2186 | do | do | I-6 | 1880 | Bored, 4-inch | 98 | 93 | 62 | 61 | Wind | 40.00 | | Domestic | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2187 | Chas. Rodger | Santa Gertrudis | I-6 | 1884 | Bored, 4-inch | 96 | 96 | 299 | 28 | Artesian | $400.00 | | Stock; domestic. | Small. |
| 2188 | Theo. Foster | do | I-7 | 1883 | Bored, 7-inch | 96 | 96 | 275 | 26 | Artesian, hand | 700.00 | | Domestic | |
| 2189 | Mr. Isabel | do | I-7 | 1903 | Bored, 5-inch | 92 | 87 | 98 | 56 | Hand | | | Stock | |
| 2190 | J. V. Dilley | Los Coyotes | I-7 | 1885 | Bored, 7-inch | 87 | 90 | 311 | 24 | Artesian | 400.00 | | Domestic; stock. | Small. |
| 2191 | do | do | J-7 | 1883? | do | 93 | 90 | 160 | | | 175.00 | | Stock | |
| 2192 | do | do | J-7 | 1875 | do | 96 | 96 | 280 | 27 | Wind | 800.00 | $113.00 | Domestic | |
| 2193 | do | do | J-7 | 1902 | Bored, 2-inch | 94 | 94 | 200 | 26 | Artesian | 200.00 | | Stock | Small. |
| 2194 | Mrs. E. Baker | Santa Gertrudis | I-6 | 1895 | do | 100 | | 90 | 61 | Wind | | | Domestic | |
| 2195 | S Baker | do | J-6 | 1888 | Bored, 8-inch | 100 | 100 | 350 | 28 | | 1,050.00 | | do | Small. |
| 2196 | Atwood Sproul | Los Coyotes | J-6 | 1875 | Bored, 7-inch | 99 | 99 | 457 | 26 | Artesian | 2,200.00 | | do | †3 |
| 2197 | Union Oil Co | do | J-7 | 1902 | Bored, 4-inch | 98 | 87 | 87 | 35 | | | | Boilers? | |
| 2198 | A. Sproul | do | J-7 | 1870? | Bored, 7-inch | 97 | 86 | 250 | 37 | Wind | | | Stock | |
| 2199 | Railroad station | do | J-7 | 1903 | Bored, 9½-inch | 98 | 86 | 118 | 47 | Not installed | 215.00 | | | |
| 2200 | A. R. Sebastian | do | J-7 | 1901 | Bored, 2-inch | 98 | 86 | 97 | 42 | Wind | 35.00 | 200.00 | Domestic | |
| 2201 | E. P. Pruitt | do | J-7 | 1900 | do | 98 | 86 | 108 | 48 | do | 55.00 | 145.00 | do | |
| 2202 | Belle-Vernon Farms Co. | do | J-7 | 1891 | Bored, 4-inch | 95 | | 100 | 43 | Hand | 100.00 | | do | |
| 2203 | H. G. Borroughs | do | J-7 | 1901 | Bored, 2-inch | 95 | 84 | 110 | 42 | Wind | 55.00 | 125.00 | do | |
| 2204 | M. D. Fraser | do | J-7 | 1902 | Bored, 4-inch | 95 | 83 | 104 | | do | 82.00 | 250.00 | do | |
| 2205 | W. Waymayer | do | J-7 | 1895? | Bored, 2-inch | 94 | | | 22 | do | | | do | |
| 2206 | W. H. Smith | do | J-7 | 1902 | do | 94 | | 100 | 40 | do | 50.00 | 240.00 | do | |
| 2207 | J. Seabridge | do | J-7 | 1901 | do | 93 | 81 | 100 | 40 | do | 55.00 | | do | |
| 2208 | J. J. Blair | do | J-7 | 1903 | do | 93 | 82 | 98 | 41 | do | 44.00 | 125.00 | do | |
| 2209 | J. Haddock | do | J-7 | 1901 | do | 92 | 81 | 110 | 41 | do | 45.00 | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2210 | G. W. Sales | do | J-7 | 1898 | do | 92 | 92 | 640 | 36 | Artesian | | | do | | Small. |
| 2211 | Public school | do | J-7 | 1901 | do | 91 | | 106 | 38 | Wind | 45.00 | | do | | |
| 2212 | E. A. Branscon | Santa Gertrudis | I-7 | 1895 | do | 89 | 87 | 110 | 50 | Hand | 50.00 | | do | | |
| 2213 | Geo. Branscon | do | I-7 | 1893 | Bored, 4-inch | 86 | | 105 | 49 | Wind | | | do | | |
| 2214 | C. A. Phillips | do | H-7 | 1894? | Bored, 1½-inch | 83 | 82 | 120 | | do | 40.00 | | Stock | | |
| 2215 | J. T. Hall | do | I-7 | 1891 | Bored, 2-inch | 80 | | 55 | 40 | Hand | 35.00 | | Domestic | | |
| 2216 | E. A. Branscon | do | I-7 | 1880 | Bored, 4-inch | 89 | 90 | 300+ | 25 | Artesian | | | Stock | | Small. |
| 2217 | John Meeks | do | H-7 | 1873 | Bored, 7-inch | 89 | 89 | 300 | 40 | Hand | | | Domestic | | |
| 2218 | do | do | H-6 | 1874 | do | 90 | 90 | 408 | 25 | Artesian | 1,600.00 | | Stock | | 1 |
| 2219 | John Branscon | do | H-1,7 | 1895 | Bored, 4-inch | 91 | 89 | 55 | 38 | Hand | 35.00 | | Domestic | | |
| 2220 | Mr. Jerome | do | H-6 | | do | 91 | 88 | 56 | 45 | do | | | do | | |
| 2221 | A. M. Cox | do | H-6 | 1902 | Bored, 5-inch | 100 | | 62 | 49 | do | 60.00 | | do | | |
| 2222 | J. Moisa | do | H-6 | 1902 | Bored | 102 | | 72? | 57 | do | | | do | | |
| 2223 | T. W. Swain | do | H-6 | 1897 | Bored, 2-inch | 102 | | 56 | 60 | do | 30.00 | | do | | |
| 2224 | T. J. Sparks | do | H-6 | 1901 | do | 104 | 99 | 70 | 51 | do | 55.00 | | do | | |
| 2225 | T. G. Golitzer | do | H-6 | 1879? | Bored, 4-inch | 102 | 98 | 60 | 48 | do | | | do | | |
| 2226 | J. D. Evans | do | H-6 | 1885? | do | 99 | 100 | 325 | 27 | Artesian, hand | | | do | | 1 |
| 2227 | Thos. Fagan | do | H-6 | 1902 | Bored, 5-inch | 96 | 93 | 62 | 47 | Hand | 52.00 | | do | | |
| 2228 | G. A. White | do | H-6 | 1895 | Bored, 2-inch | 98 | | 91 | 43 | do | 35.00 | | do | | |
| 2229 | F. Bohring | do | H-6 | 1892 | Bored, 4-inch | 97 | 95 | 64 | 43 | do | 50.00 | | do | | |
| 2230 | Mr. Krug | do | H-6 | | do | 96 | | 66? | 41 | do | | | do | | |
| 2231 | E. E. Ball, jr. | do | H-6 | 1899 | do | 97 | | 150? | 38 | Wind | | | do | | |
| 2232 | do | do | H-6 | 1887? | do | 97 | 95 | 98 | 33 | do | 80.00 | | Domestic; stock | | |
| 2233 | G. W. Williamson | do | H-6 | 1885? | do | 98 | | 102? | 37 | do | | | Domestic | | |
| 2234 | G. A. White | do | G-6 | 1890 | do | 98 | 94 | 64 | | | 45.00 | | Not used | | |
| 2235 | John Zinn | do | G-6 | 1885? | do | 97 | 94 | 94 | 31 | Wind | 67.00 | 106.00 | Domestic | | |
| 2236 | B. Thomas | do | H-6 | 1895 | Bored, 2-inch | 93 | | 75 | | Hand | 35.00 | | do | | |
| 2237 | do | do | H-6 | 1884 | Bored, 7-inch | 92 | 92 | 240 | | | 250.00 | | Stock | | |
| 2238 | F. M. Foster | do | G-7 | 1885 | do | 92 | 89 | 250 | 24 | Hand | 300.00 | | Domestic | | |
| 2239 | O. C. Millett | do | G-6,7 | 1898 | Bored, 10-inch | 92 | 87 | 284 | | Gas | 210.00 | 520.00 | Irrigation | | †85 |
| 2240 | do | do | G-7 | 1903 | Bored, 4-inch | 90 | 86 | 86 | 31 | Hand | 68.00 | | Domestic | | |
| 2241 | G. E. Foster | do | G-7 | 1903 | Bored, 5-inch | 89 | | 84 | 33 | do | 62.00 | | do | | |
| 2242 | do | do | H-7 | 1872 | Bored, 7-inch | 89 | | 125 | 32 | do | | | do | | |
| 2243 | Mr. Wilcox | do | H-7 | | do | 88 | 86 | 108 | 39 | do | | | Stock | | |
| 2244 | W. H. Andrews | do | H-7 | 1903 | Bored, 2-inch | 96 | 81 | 96 | 40 | do | 43.00 | | Domestic; stock | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2245 | N. Davee | Santa Gertrudis | H-7 | 1893 | Dug, 3 by 4 foot | 80 | 74 | 10 | 62 | Hand | | | Domestic | |
| 2246 | F. Fleming | do | H-7 | 1902 | Bored, 4-inch | 75 | 72 | 124 | 34 | do | $104.00 | | do | |
| 2247 | C. Blythe | Los Coyotes | H-8 | 1903 | Bored, 2-inch | 74 | 73 | 104 | 34 | do | 47.00 | | do | |
| 2248 | do | do | H-8 | 1888 | do | 73 | 73 | 103 | 32 | Artesian | | | Stock | Small. |
| 2249 | Wm. Gregory | do | H-8 | 1894 | do | 74 | 74 | 150 | 29 | Wind | 90.00 | | Domestic | |
| 2250 | do | do | H-8 | 1898 | Bored, 7-inch | 73 | 73 | 100 | | Gas? | 150.00 | $85.00 | Irrigation | |
| 2251 | Mr. Hess | Los Cerritos | G-8 | 1888? | Bored, 4-inch | 77 | 74 | 126 | 30 | Hand | | | Domestic; stock | |
| 2252 | Moyse & Weaver | do | G-7 | 1888 | Bored, 5-inch | 81 | 81 | 120 | 29 | Artesian | | | Stock | |
| 2253 | James E. Hagar | do | G-8 | 1887? | Bored, 4-inch | 81 | | 80 | 21 | Hand | | | Domestic | |
| 2254 | do | do | G-7 | 1888 | Bored, 7-inch | 82 | 77 | 210 | 26 | Wind, gas | 200.00 | 640.00 | Irrigation | |
| 2255 | Mrs. Wyes | Los Coyotes | G-7 | 1887? | Bored, 4-inch | 83 | | 92 | 24 | Wind | | | Domestic | |
| 2256 | Moyse & Weaver | Los Cerritos | G-7 | 1901 | Bored, 6-inch | 85 | | 111 | 28 | do | | | do | |
| 2257 | do | do | G-7 | 1902 | Bored, 12-inch | 86 | 89 | 567 | 26 | Artesian, gas | 1,556.00 | 1,356.00 | Irrigation | +50 |
| 2258 | P. O'Connor | do | G-7 | 1901 | Bored, 2-inch | 86 | 83 | 137 | 29 | Wind | 61.50 | | Domestic | |
| 2259 | do | do | G-7 | 1897 | Bored, 10-inch | 88 | 84 | 172 | | Gas | 350.00 | 700.00 | Irrigation | 40 |
| 2260 | J. R. Cooke | do | G-7 | 1876? | Bored, 7-inch | 85 | 82 | 456 | 25 | Hand | 1,500.00 | | Domestic; stock | |
| 2261 | R. Casey | do | G-7 | 1901 | Bored, 2-inch | 88 | | 90 | 27 | do | | | Stock | |
| 2262 | H. T. Porter | Santa Gertrudis | G-7 | 1897? | do | 90 | | 116 | 30 | do | 52.00 | | Domestic | |
| 2263 | W. T. Strawbridge | do | G-7 | 1883? | Bored, 4-inch | 90 | | 120 | 29 | do | | | do | |
| 2264 | do | do | G-7 | 1898 | Bored, 10-inch | 91 | 86 | 196 | | Gas | | | Irrigation | †50 |
| 2265 | W. S. Grey | do | G-7 | 1896? | Bored, 2-inch | 91 | | 85 | 29 | Hand | 35.00 | | Domestic | |
| 2266 | do | do | G-7 | 1903 | Bored, 4-inch | 91 | | 94 | 27 | Gas | 85.00 | 200.00 | Irrigation | |
| 2267 | W. Spalding | do | G-7 | 1894? | Bored, 1½-inch | 91 | | 85 | 29 | Hand | 35.00 | | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2268 | Wm. Stooksberg | do | G-7 | 1891 | Bored, 4-inch | 93 | | 60 | 30 | do | | | do | | |
| 2269 | A. E. Brittle | do | G-7 | 1890? | Bored, 2-inch | 95 | | 82 | 30 | do | | | do | | |
| 2270 | W. H. Porter | do | G-6 | 1897 | Bored, 4-inch | 96 | | 85 | 30 | do | 75.00 | | do | | |
| 2271 | E. E. Ball | do | G-6 | 1896 | do | 97 | | 320 | 21 | Wind | 400.00 | 60.00 | do | | |
| 2272 | M. P. Snyder | do | G-6 | 1898 | Bored, 2-inch | 97 | | 75 | 31 | Hand | | | do | | |
| 2273 | J. H. Cooke | do | G-6 | 1884 | Bored, 4-inch | 100 | | 56 | 30 | Wind | | | Domestic; stock | | |
| 2274 | V. M. Hardy | do | G-6 | 1900 | Dug, 3 by 3 foot | 103 | 93 | 13 | 44 | Hand | | | Domestic | | |
| 2275 | T. Bright | do | G-6 | 1898 | Bored, 6-inch | 102 | 97 | 98 | | do | 110.00 | | Not used | | |
| 2276 | James Bacon | do | G-6 | | Bored, 4-inch | 105 | | 90 | 30 | do | | | Domestic | | |
| 2277 | Cochran & Williams, agents. | do | G-6 | | Dug, 4 by 4 foot | 103 | 98 | 16 | 66 | do | | | Stock | | |
| 2278 | do | do | H-6 | 1885? | Bored, 4-inch | 103 | | 100? | 32 | Wind | | | Domestic | | |
| 2279 | Sam. Franklin | do | H-8 | 1879? | Driven, 5-inch | 105 | | 50? | 35 | Hand | | | do | | |
| 2280 | J. Y. Stephenson | do | H-6 | 1882? | Driven, 6-inch | 104 | | 50? | 42 | do | | | do | | |
| 2281 | Mrs. B. Frankel | do | H-6 | 1895? | Driven, 4-inch | 108 | | 80 | 48 | do | 75.00 | | Domestic; stock | | |
| 2282 | N. Vanfleet | Los Coyotes | H-5 | 1883 | Bored, 7-inch | 112 | 112 | 277 | 26 | Wind, gas | 500.00 | 250.00 | Domestic; irrigation. | | 20 |
| 2283 | do | Santa Gertrudis | H-5 | 1880? | do | 112 | 106 | 325 | | | | | Not used | | |
| 2284 | W. F. Hall | do | H-5 | 1903 | Bored, 4-inch | 112 | 107 | 81 | 33 | Hand | 75.00 | | Domestic; stock | | |
| 2285 | W. H. Townsend | do | H-6 | 1888 | do | 112 | 107 | 42 | 27 | do | 40.00 | | Domestic | | |
| 2286 | Mrs. Husk | do | H-6 | 1885 | do | 113 | 108 | 64 | 29 | do | 50.00 | | do | | |
| 2287 | R. B. Carpenter | do | G-5 | 1902 | Bored, 1½-inch | 114 | | 32 | 29 | do | 20.00 | | do | | |
| 2288 | J. R. Crowell | do | G-5 | 1898 | Bored, 2-inch | 114 | | 86 | 30 | Wind | 42.00 | 125.00 | Domestic; stock | | |
| 2289 | R. B. Carpenter | do | G-5 | 1900 | Bored, 10-inch | 114 | 108 | 100 | 25 | Gas | 250.00 | | Irrigation | | 35 |
| 2290 | do | do | G-5 | 1888? | Bored 4-inch | 109 | | 65 | 31 | Wind | 52.00 | | Domestic; stock | | |
| 2291 | P. O. Rogers | do | G-5 | 1887 | do | 110 | 104 | 70 | 33 | do | 56.00 | 240.00 | Domestic | | |
| 2292 | J. E. Jannison | do | G-6 | 1887 | do | 107 | 100 | 65 | 33 | do | 52.50 | | Domestic; stock | | |
| 2293 | J. H. Cooke | do | G-6 | 1885 | do | 99 | 92 | 92 | | | 60.00 | | Not used | | |
| 2294 | R. E. Briar | do | G-6 | 1879? | do | 97 | 91 | 60 | 25 | Wind | | | Domestic; stock | | |
| 2295 | Redfield Chatman | do | F-6 | 1880? | do | 103 | 91 | 100? | 21 | do | | | do | | |
| 2296 | J. Quill | do | F-6 | 1884? | do | 100 | | 117 | 22 | Hand | 125.00 | | Domestic | | |
| 2297 | Mrs. Hewitt | do | G-6 | 1898 | Bored, 2-inch | 99 | | 90 | | do | | | do | | |
| 2298 | A. Horton | do | G-6 | | do | 98 | | 90? | 26 | do | | | do | | |
| 2299 | Joe Dismukes | do | F-6 | | Driven, 2-inch | | | 20? | | do | | | Stock | | |
| 2300 | H. A. Anderson | do | G-7 | | Bored, 4-inch | 93 | | 85? | 22 | Wind | | | Domestic | | |
| 2301 | A. Curtain | do | F-7 | 1885 | do | 95 | | 114 | 24 | do | 100.00 | 50.00 | do | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2302 | A. Curtain | Santa Gertrudis | F-6 | 1900 | Bored, 12-inch | 95 | 96 | 755 | 23 | Artesian | $2,360.00 | | Irrigation | Small. |
| 2303 | Wm. McCormick | do | F-6 | 1903 | Bored, 5-inch | 96 | 86 | 125 | 28 | Hand | 120.00 | $27.00 | Domestic | |
| 2304 | A. Curtain | do | F-6 | 1895 | Bored, 2-inch | 95 | 85 | 110 | 22 | do | 40.00 | | Stock | |
| 2305 | Downey Masons | do | G-7 | 1896? | Bored, 4-inch | 93 | | | | Wind | | | Irrigation | |
| 2306 | T. S. Beatty | Los Cerritos | G-7 | 1899 | Bored, 10-inch | 92 | 84 | 237 | | Gas | 650.00 | 700.00 | do | |
| 2307 | do | do | F-7 | 1883? | Bored, 4-inch | 92 | | 90? | 26 | Wind | | | Domestic | |
| 2308 | John Mullen | do | F-7 | 1898 | Bored, 12-inch | 89 | | 190 | | | | | Irrigation | |
| 2309 | do | do | F-7 | 1903 | Bored, 5-inch | 88 | | 150? | 26 | Wind | | | Domestic | |
| 2310 | Mrs. Petterson | do | G-7 | 1892 | Bored, 4-inch | 84 | 80 | 118 | 24 | do | | | do | |
| 2311 | G. Anderson | do | F-7 | 1898 | Bored, 9½-inch | 84 | 80 | 237 | | Gas | 360.00 | 700.00 | Irrigation | 90 |
| 2312 | do | do | F-7 | 1903 | Bored, 10-inch | 84 | 80 | 237 | | do | 350.00 | | | |
| 2313 | F. Caseres | do | F-7 | 1900 | Bored, 2-inch | 84 | 81 | 150 | 26 | Hand | 45.00 | 125.00 | Domestic | |
| 2314 | G. Anderson | do | F-7 | 1891 | Bored, 7-inch | 84 | | 233 | 25 | Wind | 300.00 | 120.00 | Domestic; stock | |
| 2315 | Fred Lechner | do | F-7 | 1902 | Bored, 5-inch | 84 | 84 | 129 | | Wind, artesian | 150.00 | | do | Small. |
| 2316 | Chas. McCurdy | do | F-7 | 1898 | Bored, 2-inch | 83 | 83 | 155 | | Hand | 62.00 | | Domestic | |
| 2317 | H. Bush | do | F-7 | 1893? | Bored, 4-inch | 82 | 78 | 110 | 28 | do | 88.00 | | do | |
| 2318 | A. Convert | do | F-7 | 1895 | Bored, 2-inch | 82 | 82 | 137 | | Artesian | 55.00 | | do | Small. |
| 2319 | do | do | F-7 | 1898 | do | 82 | 82 | 142 | 25 | do | 60.00 | | Stock | 1½ |
| 2320 | do | do | F-7 | 1902 | do | 81 | 81 | 96 | 26 | do | 40.00 | | Domestic | Small. |
| 2321 | D. O'Leary | do | F-7 | 1893 | do | 80 | 80 | 140 | 25 | Artesian, hand | 55.00 | | Domestic; stock | Small. |
| 2322 | F. W. Curtis | do | F-7 | 1901 | Bored, 5-inch | 81 | | 151 | 24 | Hand | 125.00 | | Domestic | |
| 2323 | Mr. Armstrong | do | F-8 | 1899 | Bored, 2-inch | 79 | 79 | 146 | 24 | Artesian, hand | 55.00 | | Stock; domestic | Small. |
| 2324 | E. L. Lovel | do | F-8 | 1898 | do | 78 | 78 | 630 | 25 | Artesian | 224.00 | | Domestic; irrigation. | 2 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2325 | ....do | ....do | F-8 | 1899 | ....do | 77 | 77 | 130 | 25 | Artesian, hand | 48.00 | | Stock | Small. |
| 2326 | L. Ofer | ....do | F-8 | 1893? | ....do | 77 | 77 | 140? | 26 | Artesian | | | Domestic; stock | |
| 2327 | L. Conant | ....do | F-8 | 1893? | ....do | 75 | 75 | 138 | 24 | Artesian, wind | 50.00 | | Domestic | Sma |
| 2328 | Chris. Miller | ....do | F-8 | 1900 | ....do | 72 | 72 | 155? | 24 | Artesian | 50.00 | | Stock; irrigation | |
| 2329 | ....do | ....do | F-8 | 1895 | ....do | 72 | 72 | 150 | 24 | ....do | 40.00 | | Domestic; stock | |
| 2330 | Mr. Fitzpatrick | ....do | F-8 | 1901 | ....do | 72 | | 150? | 24 | ....do | 40.00 | | ....do | 1 |
| 2331 | Axle Anderson | ....do | F-8 | 1899 | Bored, 3-inch | 71 | 71 | 160 | 25 | ....do | 36.00 | | Domestic; stock; irrigation. | 1 |
| 2332 | A. J. Staly | ....do | F-8 | 1894? | ....do | 70 | 70 | 144 | 24 | ....do | 70.00 | | Domestic; stock | |
| 2333 | ....do | ....do | F-8 | 1897? | ....do | 70 | 70 | 140 | | ....do | 75.00 | | Irrigation; stock | |
| 2334 | John Anderson | ....do | F-9 | 1900 | Bored, 10-inch | 68 | 68 | 675 | 24 | ....do | 1,400.00 | | Irrigation | |
| 2335 | M. N. Pousey | ....do | F-9 | 1896 | Bored, 2-inch | 69 | 69 | 205 | 27 | ....do | 83.00 | | Domestic | Small. |
| 2336 | John Anderson | ....do | F-9 | 1894 | ....do | 69 | 69 | 260 | | ....do | 110.00 | | Not used | |
| 2337 | ....do | ....do | F-9 | 1895 | ....do | 69 | 69 | 260 | 26 | ....do | 110.00 | | Domestic | Small |
| 2338 | C. P. Eldridge | ....do | F-9 | 1896 | Bored, 3-inch | 70 | 70 | 610 | 24 | ....do | 150.00 | | ....do | |
| 2339 | P. H. Clark | Santa Gertrudis | F-9 | 1891? | ....do | 71 | 71 | 248 | 24 | Artesian, wind | | | ....do | Small. |
| 2340 | C. H. Kirby | Los Cerritos | E-9 | 1896? | Bored, 2-inch | 64 | 64 | 560 | 24 | Artesian | 224.00 | | Domestic; stock | Small. |
| 2341 | ....do | ....do | E-9 | 1898 | ....do | 64 | 64 | 168 | 24 | ....do | | | Irrigation | 2 |
| 2342 | ....do | ....do | E-9 | 1898 | ....do | 64 | 64 | 178 | 26 | ....do | 65.00 | | ....do | †1 |
| 2343 | ....do | ....do | E-9 | 1892? | Bored, 4-inch | 64 | 67 | 145? | 25 | ....do | | | Stock | Small. |
| 2344 | J. D. Fredericks | ....do | F-9 | 1898 | Bored, 2-inch | 65 | 65 | 588 | 33 | ....do | 235.00 | | Stock; domestic | |
| 2345 | A. I. Stewart | ....do | E-9 | 1901 | ....do | 65 | 65 | 190 | 24 | Artesian, hand | 80.00 | | Domestic | Small. |
| 2346 | ....do | ....do | E-9 | 1894? | Bored, 4-inch | 66 | 66 | 600? | 24 | Gas | 350.00 | | Irrigation | |
| 2347 | J. H. Patterson | ....do | F-9 | 1899? | Bored, 3-inch | 66 | 66 | 760? | 27 | Artesian | | | Domestic; irrigation. | |
| 2348 | A. McKelvey | ....do | E-9 | 1898 | Bored, 2-inch | 68 | 68 | 226 | 25 | Hand | 90.00 | | Domestic | |
| 2349 | J. C. Caldwell, agent | ....do | E-9 | 1902 | ....do | 69 | 69 | 554 | 24 | Artesian | 250.00 | | ....do | 2 |
| 2350 | Mrs. A. Blanc | ....do | F-9 | 1899 | Bored, 4-inch | 69 | 69 | 630? | 26 | ....do | | | Domestic; irrigation. | 5 |
| 2351 | Alex. Stewart | ....do | F-9 | 1897 | Bored, 2-inch | 69 | 69 | 630 | 24 | ....do | 120.00 | | ....do | |
| 2352 | C. H. Longhery | ....do | E-9 | 1901 | ....do | 70 | 70 | 182 | 24 | Wind | 82.00 | | Domestic | |
| 2353 | H. P. Epperson | ....do | E-8, 9 | 1895 | ....do | 70 | 70 | 300 | 24 | Artesian, wind | 300.00 | | ....do | Small. |
| 2354 | ....do | ....do | E-8 | 1895 | ....do | 70 | 70 | 616 | 23 | Artesian | 300.00 | | ....do | |
| 2355 | ....do | ....do | E-8, 9 | 1895 | ....do | 70 | 70 | 615 | | ....do | 300.00 | | ....do | |
| 2356 | T. F. Downs | ....do | F-8 | 1903 | ....do | 70 | 70 | 140 | 21 | Hand | 60.00 | | ....do | |
| 2357 | John Clark | ....do | F-8 | 1898 | ....do | 70 | 70 | 140 | 25 | ....do | 60.00 | | ....do | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2358 | Hynes Irrigation Co. | Los Cerritos | E-8 | 1898 | Bored, 12-inch | 71 | 71 | 253 | 22 | Gas | | $700.00 | Irrigation | †100 |
| 2359 | E. T. Thwing | do | E-8 | 1899 | Bored, 2-inch | 72 | 72 | 615 | 25 | Artesian | $180.00 | | Domestic | |
| 2360 | M. A. Pilkey | do | E-8 | 1896? | do | 72 | 72 | 150 | 26 | do | 65.00 | | do | |
| 2361 | J. Jahnke | do | E-8 | 1903 | do | 72 | 72 | 145 | | Hand | 65.00 | | do | |
| 2362 | Mrs. Letner | do | E-8 | 1903 | do | 72 | 72 | 147 | 25 | Artesian | 67.00 | | do | |
| 2363 | Chas. Harman | do | F-8 | 1897? | Dug, 3 by 3 foot | 73 | 67 | 8 | 53 | Hand | | | do | |
| 2364 | E. T. Fuller | do | F-8 | 1895 | Dug, 2 by 3 foot | 73 | 67 | 7 | 56 | do | | | do | |
| 2365 | H. L. Covell | do | F-8 | 1896? | Bored, 2-inch | 73 | 73 | 150 | | Artesian, hand | 65.00 | | do | |
| 2366 | do | do | F-8 | 1898 | do | 73 | 73 | 150 | 24 | Hand, artesian | 65.00 | | do | |
| 2367 | F. F. Howard | do | F-8 | 1893 | Bored, 4-inch | 73 | 73 | 150 | 25 | do | 150.00 | | Domestic; stock | Small. |
| 2368 | Mrs. Chas. Wilds | do | F-8 | 1899 | Bored, 2-inch | 74 | 74 | 150 | 24 | Artesian | 65.00 | | do | 2 |
| 2369 | John Steneman | do | F-8 | 1897 | do | 73 | 73 | 150 | 22 | Hand, artesian | 50.00 | | Domestic; irrigation. | Small. |
| 2370 | Mrs. Thompson | do | F-8 | 1890? | do | 73 | 73 | 135 | 23 | Artesian | | | Domestic | |
| 2371 | G. W. Williams | do | F-8 | 1895 | do | 73 | 73 | 148 | 24 | Artesian, hand | 60.00 | | do | 1 |
| 2372 | J. F. King | do | E-8 | 1897 | do | 73 | 73 | 146 | 25 | Artesian | 55.00 | | Domestic; stock | 2 |
| 2373 | Mrs. G. Geryalva | do | F-8 | 1901 | Dug, 3 by 3 foot | 74 | 68 | 8 | | Hand | | | Domestic | |
| 2374 | Chas. Wilder | do | F-8 | 1901 | Bored, 2-inch | 74 | 74 | 152 | 25 | Artesian | | | Domestic; stock | †1 |
| 2375 | G. E. Robdin | do | F-8 | 1897 | do | 75 | 75 | 160 | 24 | do | 63.50 | | Domestic | Small. |
| 2376 | School | do | F-8 | 1893 | do | 75 | 75 | 152 | 22 | Wind | 65.00 | 125.00 | do | |
| 2377 | W. M. Squires | do | F-8 | 1895? | do | 75 | 75 | 168 | 24 | Artesian | 70.00 | | do | †1 |
| 2378 | J. Q. Hall | do | E, F-8 | 1897 | do | 74 | 74 | 160 | 25 | Hand | 64.00 | | do | |
| 2379 | Mrs. Gaines | do | F-8 | 1895? | do | 74 | 74 | 154 | 24 | Artesian, hand | 60.00 | | do | Small. |
| 2380 | Tom Gregory | do | E-8 | 1903 | do | 73 | 73 | 155 | 22 | Artesian | | | Domestic; stock | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2381 | J. B. Smith | do | E-8 | 1901 | Dug, 2½ by 2½ foot | 72 | 68 | 6 | 65 | Hand | | | Stock | |
| 2382 | A. L. Austin | do | E-8 | 1896 | Bored, 1½-inch | 73 | 73 | 157 | 27 | Artesian, hand | 60.00 | | Domestic | Small. |
| 2383 | T. F. Stansberry | do | E-8 | 1897? | Bored, 2-inch | 74 | 74 | 365 | 24 | Artesian | 230.00 | | Irrigation | Small. |
| 2384 | do | do | E-8 | 1894? | Bored, 7-inch | 74 | 74 | 287 | 24 | Wind, artesian | 390.00 | 75.00 | Irrigation; domestic. | Small. |
| 2385 | A. E. Chapman | do | E-8 | 1893? | Bored, 3-inch | 74 | 73 | 160 | 24 | Hand | | | Domestic | |
| 2386 | W. T. Carter | do | E-8 | 1895 | Bored, 2-inch | 74 | 73 | 217 | 24 | do | 90.00 | | do | |
| 2387 | do | do | E-8 | 1895 | do | 74 | 74 | 165 | 23 | Hand, artesian | 65.00 | | do | Small. |
| 2388 | A. Perkins | do | E-8 | 1903 | do | 74 | 74 | 159 | 25 | Hand | 65.00 | | do | |
| 2389 | James Hill | do | E-8 | 1901 | do | 75 | 75 | 168 | 23 | Wind | 65.00 | | do | |
| 2390 | Mrs. Kingston | do | F-8 | 1899 | Driven, 1¼-inch | 75 | | 14 | 46 | Hand | | | do | |
| 2391 | E. A. Rogers | do | E-8 | 1886? | Bored, 7-inch | 77 | 76 | 190 | 24 | Wind | 380.00 | 75.00 | do | |
| 2392 | do | do | E-8 | 1898 | Bored, 2-inch | 77 | 77 | 176 | 23 | Artesian | 80.00 | | Irrigation | 2 |
| 2393 | W. C. Thomas | do | E-8 | 1901 | do | 75 | 75 | 153 | 25 | do | 65.00 | | Domestic | Small. |
| 2394 | Mr. Patterson | do | E-8 | 1899? | do | 75 | | 140? | 25 | Wind | 55.00 | | do | |
| 2395 | D. R. Bell | do | E-8 | 1903 | do | 75 | 75 | 156 | 26 | Hand | 65.00 | | do | |
| 2396 | W. Malcom | do | E, F-8 | | do | 75 | | 90? | | do | | | do | |
| 2397 | Geo. Spafford | do | E, F-8 | 1902 | do | 75 | 75 | 177 | 33 | Artesian, hand | 70.00 | 10.00 | do | Small. |
| 2398 | Geo. H. Meissen | do | F-8 | 1903 | Bored, 7-inch | 76 | 76 | 142 | 27 | Artesian | 284.00 | | Irrigation | 5 |
| 2399 | do | do | F-8 | 1902 | Bored, 2-inch | 76 | 76 | 168 | 25 | do | 75.00 | | Domestic | 1 |
| 2400 | I. A. Sharp | do | F-8 | 1893 | do | 77 | 77 | 135 | 25 | Artesian, hand | 60.00 | | Domestic; stock | Small. |
| 2401 | do | do | F-8 | 1900 | Bored, 4-inch | 77 | 77 | 140 | 22 | Artesian | 110.00 | | Irrigation | †3 |
| 2402 | Theo. Ice | do | F-8 | 1899 | Bored, 2-inch | 77 | 77 | 144 | 22 | do | 45.00 | | Stock | 1½ |
| 2403 | do | do | F-8 | 1900 | do | 77 | 77 | 171 | | do | 51.00 | | do | †2 |
| 2404 | do | do | F-8 | 1892? | Bored, 7-inch | 78 | 78 | 163 | 24 | Hand | | | Domestic; stock | Small. |
| 2405 | R. R. Briggs | do | F-7 | 1890? | Bored, 4-inch | 80 | 80 | 150? | 25 | Wind | | | do | |
| 2406 | I. Mitchler | do | E-7 | 1897 | Bored, 2-inch | 79 | 79 | 144 | 26 | Artesian, hand | 60.00 | | Domestic | †2 |
| 2407 | Robert A. King | do | E-7 | 1896 | do | 82 | 82 | 156 | 24 | Wind, artesian | 60.00 | | do | Small. |
| 2408 | F. Ealey | do | E-7 | 1897 | do | 82 | 82 | 144 | 27 | Hand, artesian | 50.00 | | do | Small. |
| 2409 | Mr. McClure | do | E-7 | 1888 | Bored, 6-inch | 83 | 83 | 160 | 25 | Wind | | | Domestic; stock | |
| 2410 | P. Bohn | do | E, F-7 | 1890? | Bored, 2-inch | 84 | 84 | 140 | 26 | Hand | 55.00 | | Domestic | |
| 2411 | do | do | F-7 | 1901 | Bored, 12-inch | 87 | 87 | 158 | 25 | Gas, artesian | 450.00 | 775.00 | Irrigation | †60 |
| 2412 | D. Gemmill | do | F-7 | 1894 | Bored, 2-inch | 88 | 88 | 134 | 26 | Hand | 60.00 | | Domestic | |
| 2413 | do | do | F-7 | 1896 | do | 88 | 88 | 150 | | do | 50.00 | | Stock | |
| 2414 | do | do | F-7 | 1896 | do | 88 | 88 | 150 | 25 | Artesian | 50.00 | | do | Small. |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2415 | Mr. Bacon | Santa Gertrudis | F-6 | 1893 | Bored, 7-inch | 95 | 95 | 300? | 27 | Wind | | | Stock | |
| 2416 | do | do | F-6 | 1883? | do | 96 | 94 | 109 | 26 | Hand | | | do | |
| 2417 | D. Lane | do | F-6 | 1899 | Bored, 2-inch | 97 | 92 | 140 | 29 | Wind | $100.00 | | Domestic; stock | |
| 2418 | G. W. Holcomb | do | F-6 | 1895? | Bored, 4-inch | 100 | 92 | 110 | 28 | do | 55.00 | | Domestic | |
| 2419 | J. W. Venable | do | F-6 | 1876 | do | 100 | 92 | 68 | 29 | do | 33.00 | $50.00 | do | |
| 2420 | M. McCurdy | do | F-6 | 1898? | Driven, 1½-inch | 101 | | 16 | 36 | Hand | | | do | |
| 2421 | C. Brown | do | F-6 | 1887 | Bored, 7-inch | 102 | 94 | 100 | 27 | Wind | | | do | |
| 2422 | Thos. Grider | do | F-6 | 1898 | Driven, 1½-inch | 102 | | 85 | 30 | Hand | 40.00 | | do | |
| 2423 | do | do | F-6 | 1880 | Dug, 2½ by 2½ foot | 102 | 92 | 14 | 53 | do | | | Stock | |
| 2424 | J. W. Brown | do | F-6 | 1889 | Bored, 4-inch | 103 | | 112 | 30 | Wind | 112.00 | 50.00 | do | |
| 2425 | James Quill | do | F-6 | 1883 | do | 103 | | 125 | 28 | do | | | Domestic | |
| 2426 | do | do | F-5 | 1883 | do | 103 | | 85 | 29 | Hand | | | Stock | |
| 2427 | do | do | F-6 | 1883 | do | 104 | 91 | 98 | 23 | | | | Not used | |
| 2428 | B. L. Barnett | do | F-6 | 1893 | do | 104 | 91 | 160? | 29 | Wind | | | Domestic | |
| 2429 | C. B. Reddick | do | F-5 | 1893? | Driven, 1½-inch | 106 | | 60? | 43 | Hand | | | do | |
| 2430 | Mrs. Clayton | do | F-6 | 1888 | Bored, 4-inch | 105 | 91 | 85? | 32 | Wind | | | do | |
| 2431 | J. H. Cooke | do | F-6 | 1884 | do | 105 | 92 | 86 | 28 | do | 60.00 | | do | |
| 2432 | Mrs. Briggs | do | F-6 | 1896? | Bored, 5-inch | 105 | 94 | 98 | 26 | do | | | do | |
| 2433 | J. De Plaa | do | F-5 | | Dug, 2 by 3 foot | 106 | 96 | 12 | | Hand | | | do | |
| 2434 | L. L. Easterly | do | F-6 | | Driven, 1½-inch | 106 | | 35? | 32 | do | | | do | |
| 2435 | J. H. Aidis | do | F-5 | 1891? | Bored, 4-inch | 107 | | 90 | 30 | Wind | | | do | |
| 2436 | Chas. Butler | do | F-6 | | do | 106 | 95 | 75 | 26 | Hand | | | do | |
| 2437 | Mr. Cookingham | do | G-6 | 1896 | Bored, 2-inch | 107 | | 97 | | Wind | 48.00 | 60.00 | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2438 | J. Ullery | do | G-6 | 1888 | Bored, 4-inch | 107 | 96 | 105 | 28 | do | 70.00 | 65.00 | do | | |
| 2439 | Mrs. T. J. Kearns | do | G-6 | 1882 | do | 108 | 96 | 86 | 46 | do | 70.00 | | do | | |
| 2440 | Mrs. J. Butler | do | G-6 | 1882 | do | 107 | | 88 | 29 | Hand | 70.00 | | do | | |
| 2441 | F. Bohn | do | G-6 | 1901 | do | 103 | | 100 | 27 | Wind | 73.00 | 150.00 | do | | |
| 2442 | do | do | G-6 | 1882 | do | 103 | | 90 | 27 | do | | | Stock | | |
| 2443 | Alameda School | do | G-6 | 1899 | do | 104 | | 86 | 26 | Hand | | | Domestic | | |
| 2444 | B. P. Patten | do | G-5 | 1896 | Dug, 2-foot diam. | 110 | | 82 | 28 | do | 40.00 | | do | | |
| 2445 | F. Stout | do | G-5 | 1885? | Driven, 2-inch | 110 | | 76 | | do | | | do | | |
| 2446 | B. P. Patten | do | G-5 | 1885? | Bored, 4-inch | 111 | | 86 | 28 | do | 65.00 | | do | | |
| 2447 | R. B. Alexander | do | G-5 | 1897 | Hydraulic, 2-inch. | 112 | | 78 | 33 | Wind | 27.00 | | do | | |
| 2448 | A. Buhler | do | G-5 | 1875? | Bored, 6-inch | 112 | 98 | 108 | 29 | do | | | do | | |
| 2449 | F. Smith | do | G-5 | 1898? | Bored, 2-inch | 113 | | 82 | 32 | Hand | | | do | | |
| 2450 | W. W. Walk | do | G-5 | 1893 | Driven, 1½-inch | 114 | | 87 | 33 | do | 40.00 | | do | | |
| 2451 | G. W. Snyder | do | G-5 | 1889 | Bored, 4-inch | 114 | 104 | 86 | 30 | Wind | 40.00 | | do | | |
| 2452 | Erven Gillies | do | G-5 | 1889 | do | 114 | | 86 | 30 | Hand | 70.00 | | do | | |
| 2453 | L. F. Jones | do | G-5 | 1901 | Bored, 2-inch | 115 | | 87 | 27 | do | 65.00 | | do | | |
| 2454 | O. P. Towne | do | G-5 | 1880? | Dug, 2½ by 2½ foot. | 115 | 108 | 10 | 51 | do | | | do | | |
| 2455 | do | do | G-5 | 1880? | Dug, 2½ by 3 foot | 116 | 108 | 11 | 200+ | do | | | Stock | | |
| 2456 | M. E. Scummins | do | G-5 | 1885 | Bored, 2-inch | 115 | | 76 | 34 | do | | | Domestic | | |
| 2457 | A. B. Walk | do | G-5 | 1901 | Bored, 4-inch | 115 | | 84 | 35 | do | | | do | | |
| 2458 | Miss Knight | do | G-5 | 1902? | do | 114 | 104 | 80 | 28 | do | | | do | | |
| 2459 | John McCommic | do | G-5 | | do | 114 | | 80 | 28 | do | 60.00 | | do | | |
| 2460 | Mr. Graham | do | G-5 | 1887? | do | 114 | | 83 | 31 | do | 64.00 | | Domestic; stock | | |
| 2461 | A. M. Thompson | do | G-5 | 1902 | do | 115 | 105 | 96 | 30 | Wind | 62.00 | 40.00 | Domestic | | |
| 2462 | Mrs. Weis | do | G-5 | 1884 | Bored, 7-inch | 116 | 105 | 90 | 29 | Steam | | | Winery | | |
| 2463 | do | do | G-5 | 1887 | do | 115 | 105 | 90 | 29 | Wind | | | Domestic | | |
| 2464 | John Stewart | do | G-5 | 1888 | Bored, 4-inch | 117 | | 96 | 31 | Hand | 90.00 | | do | | |
| 2465 | do | do | G-5 | 1894? | Bored, 2-inch | 115 | | 88 | 31 | do | | | do | | |
| 2466 | J. H. Strine | do | G-5 | 1883 | Bored, 4-inch | 115 | 105 | 90 | 28 | do | 70.00 | | do | | |
| 2467 | W. J. Snyder | do | G-5 | 1903 | Bored, 5-inch | 115 | 105 | 87 | 26 | do | 88.00 | | do | | |
| 2468 | W. W. Bramlett | do | G-5 | 1903 | Bored, 7-inch | 115 | 105 | 87 | 28 | do | 110.00 | | do | | |
| 2469 | Mrs. Houston | do | G-5 | 1888 | Bored, 4-inch | 114 | | 86 | 26 | do | | | do | | |
| 2470 | A. J. Bramlett | do | G-5 | 1891 | Bored, 2-inch | 114 | | 90 | 31 | do | 45.00 | | do | | |
| 2471 | R. M. Moore | do | G-5 | 1887 | Bored, 4-inch | 115 | 113 | 96 | 30 | do | 72.00 | | do | | |
| 2472 | J. W. Woolliscroft | do | G-5 | 1898 | do | 113 | 103 | 91 | 28 | Wind | 70.00 | | do | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2473 | H. A. Scott | Santa Gertrudis | G-5 | 1888 | Bored, 4-inch | 111 | 100 | 96 | 29 | Wind | $78.00 | $75.00 | Domestic | |
| 2474 | E. A. Brunson | do | G-5 | 1902 | do | 109 | 99 | 96 | 39 | Hand | 78.00 | | do | |
| 2475 | do | do | G-5 | 1896 | Hydraulic, 1½-inch | 110 | | 109 | 30 | do | 50.00 | | Stock | |
| 2476 | L. Ullery | do | G-5 | 1888 | Driven, 1½-inch | 189 | | 16 | 86 | do | 7.00 | | Domestic | |
| 2477 | H. A. Mosher | do | G-5 | 1899 | Bored, 4-inch | 109 | 98 | 77 | 29 | do | 58.00 | | do | |
| 2478 | M. L. Holcom | do | G-5 | 1899 | Driven, 1½-inch | 109 | | 29 | 38 | do | | | do | |
| 2479 | J. C. Ullery | do | G-5 | 1900 | Bored, 2-inch | 108 | | 96 | 28 | do | 45.00 | | do | |
| 2480 | S. A. Wayne | do | F-5 | 1888? | Bored, 4-inch | 109 | | 90 | 29 | Wind | 70.00 | | do | |
| 2481 | H. H. Felch | do | F-5 | 1883? | Bored, 5-inch | 108 | 95 | 74 | | Hand | | | Domestic; stock | |
| 2482 | E. P. Dismukes | do | F-5 | 1902 | Bored, 4-inch | 107 | 97 | 84 | 27 | do | 68.00 | | Stock | |
| 2483 | C. F. Mackley | do | F-5 | 1895 | Bored, 2-inch | 109 | | 90 | 30 | do | 45.00 | | Domestic | |
| 2484 | T. F. Renfro | do | F, G-5 | 1888 | Bored, 4-inch | 110 | 100 | 19 | 51 | Wind | 16.00 | | Stock | |
| 2485 | do | do | G-5 | | Driven, 1½-inch | 110 | | 20 | 69 | Hand | | | Domestic | |
| 2486 | Dr. J. C. Kendrick | do | F-5 | 1888 | do | 111 | | 19 | 34 | do | 8.00 | | do | |
| 2487 | do | do | F-5 | 1901 | Dug, 3 by 6 foot | 111 | 102 | 10 | 56 | do | | | Stock | |
| 2488 | E. P. Dismukes | do | G-5 | 1900 | Hydraulic, 2-inch | 113 | | 96 | 30 | Wind | 45.00 | | do | |
| 2489 | D. E. Darrow | do | G-5 | 1888 | Bored, 4-inch | 113 | 104 | 85 | 29 | do | 80.00 | 150.00 | Domestic | |
| 2490 | P. F. Ryan | do | G-5 | 1898? | Driven, 1½-inch | 113 | | 20 | 40 | Hand | | | do | |
| 2491 | Wm. Bischoff | do | G-5 | 1902 | Driven, 4-inch | 114 | 107 | 16 | 25 | do | 18.00 | | do | |
| 2492 | F. Dubio | do | G-5 | 1900 | Bored, 4-inch | 115 | 105 | 96 | 31 | do | 75.00 | | Domestic; stock | |
| 2493 | O. E. Gunter | do | G-5 | 1894? | do | 115 | 107 | 19 | 27 | do | 15.00 | | Domestic | |
| 2494 | Mrs. Wilson | do | G-5 | 1900 | do | 116 | | 18 | 28 | do | 16.50 | | do | |
| 2495 | do | do | G-5 | 1901 | do | 116 | 107 | 20 | 37 | do | 19.00 | | Stock | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2496 | L. N. Zahrt | do | G-5 | 1901 | do | 116 | | 60 | 20 | do | 70.00 | | Domestic | | |
| 2497 | do | do | G-5 | 1895? | Driven, 1¼-inch | 116 | | 60 | 41 | do | 10.00 | | Stock | | |
| 2498 | W. H. Mather | do | G-5 | 1901 | Bored, 5-inch | 117 | | 96 | 33 | do | 75.00 | | Domestic | | |
| 2499 | Chas. E. Smith | do | G-5 | 1898 | Bored, 4-inch | 117 | | 92 | 30 | Wind | 65.00 | 60.00 | do | | |
| 2500 | H. D. Huggins estate | do | G-5 | 1894? | do | 116 | | 94 | 29 | Hand | 80.00 | | do | | |
| 2501 | O. Moores | do | F-4 | 1897 | Hydraulic, 2-inch | 114 | | 90? | 29 | do | | | do | | |
| 2502 | H. Hood | do | F-5 | 1903 | Bored, 5-inch | 114 | | 94 | 30 | do | 85.00 | | do | | |
| 2503 | T. R. Bagley | do | F-5 | 1903 | do | 111 | 105 | 97 | 29 | Wind | 92.00 | 35.00 | Domestic; stock | | |
| 2504 | do | do | F-5 | 1884 | Driven, 1½-inch | 111 | | 23 | 22 | Hand | | | Domestic | | |
| 2505 | O. T. Stoube | do | F-5 | 1899 | Bored, 10-inch | 111 | 103 | 120 | | Steam | 210.00 | 535.00 | Irrigation | | †80 |
| 2506 | do | do | F-5 | 1899 | Hydraulic, 3-inch | 111 | | 88 | 28 | Hand | 55.00 | | Domestic | | |
| 2507 | E. M. Allen | do | F-5 | 1890 | Bored, 4-inch | 112 | | 87 | 30 | do | 65.00 | | do | | |
| 2508 | R. E. Taylor | do | F-5 | 1903 | Bored, 5-inch | 110 | | 98 | 67 | do | 95.00 | | do | | |
| 2509 | J. R. Wright | do | F-5 | 1885? | Bored, 4-inch | 110 | | 96 | 27 | Wind | 70.00 | | do | | |
| 2510 | W. W. Wright | do | F-5 | 1898 | do | 110 | 100 | 98 | 29 | do | 75.00 | | do | | |
| 2511 | J. E. Parker | do | F-5 | 1896? | do | 108 | | 102 | 29 | do | 72.00 | | Domestic; stock | | |
| 2512 | E. P. Dismukes | do | F-5 | 1888 | do | 108 | 99 | 98 | 28 | do | 76.00 | | do | | |
| 2513 | S. M. Adams | do | F-5 | 1901 | do | 107 | 97 | 98 | 47 | Hand | 75.00 | 14.00 | Domestic | | |
| 2514 | J. G. Slingerland | do | F-5 | 1894? | do | 106 | 97 | 93 | | Wind | 70.00 | 40.00 | do | | |
| 2515 | E. L. Vaughn | do | F-5 | 1897 | Bored, 2-inch | 112 | | 103 | 33 | Hand | 40.00 | | do | | |
| 2516 | do | do | F-5 | 1903 | Dug, 3 by 3 foot | 109 | 104 | 12 | 91 | do | 19.00 | | Stock | | |
| 2517 | N. G. Thomas | do | F-5 | 1891 | Bored, 2-inch | 107 | | 97 | 32 | do | 45.00 | | Domestic | | |
| 2518 | Mrs. J. T. Saunders | do | F-5 | 1882? | Bored, 4-inch | 106 | 91 | 50 | 26 | Wind | | | Domestic; irrigation. | | |
| 2519 | Geo. Leleritz | do | F-5 | 1902 | do | 103 | | 98 | 26 | Hand | 78.00 | | Domestic | | |
| 2520 | Mr. Janka | do | F-5 | | Bored, 2-inch | 102 | | 101 | 26 | Wind | | | do | | |
| 2521 | R. P. Young | do | F-5 | 1887? | Dug, 3 by 3 foot | 100 | 92 | 12 | 62 | Hand | | | do | | |
| 2522 | County Farm | do | F-5 | | do | 98 | 92 | 8 | 47 | do | | | Stock | | |
| 2523 | P. Mussachie | do | F-5 | 1901 | Bored, 4-inch | 99 | 93 | 87 | 25 | do | 67.00 | | Domestic | | |
| 2524 | W. M. Mansfield | do | F-5 | 1901 | Bored, 2-inch | 99 | | 100 | 24 | do | 45.00 | | do | | |
| 2525 | A. Monteleone | do | F-5 | 1884 | Bored, 4-inch | 98 | 92 | 100 | 24 | do | 105.00 | | do | | |
| 2526 | do | do | E, F-5 | 1884 | do | 97 | | 115 | 25 | Wind | 110.00 | | Domestic; stock | | |
| 2527 | Old River School | do | F-5 | 1889? | do | 98 | 92 | 110 | 27 | Hand | 80.00 | | Domestic | | |
| 2528 | Mrs. L. S. Clayton | do | F-5 | 1898? | do | 102 | 94 | 92 | 29 | Wind | | | do | | |
| 2529 | County Farm | do | F-6 | 1896? | Bored, 12-inch | 101 | 92 | 178 | 28 | Compressed air | *2,000.00 | | Irrigation | | †100 |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2530 | W. A. Horton | Santa Gertrudis | F-6 | 1891 | Bored, 7-inch | 98 | 90 | 126 | 27 | Wind | | $45.00 | Domestic | |
| 2531 | County Farm | do | E-6 | 1888? | do | 93 | 89 | 185 | 29 | Gas | | | Domestic; irrigation. | †4 |
| 2532 | Geo. L. Rognon | do | E-5 | 1901 | Bored, 4-inch | 98 | 94 | 106 | 26 | Hand | $74.00 | 8.00 | Domestic | |
| 2533 | Salt Lake terminal | do | E-5 | 1903 | Bored, 2-inch | 99 | | 80 | | do | | | do | |
| 2534 | E. Gunn | do | E-5 | 1903 | Bored, 12-inch | 102 | 94 | 280 | 24 | Gas | | | Irrigation | 180 |
| 2535 | do | do | E-5 | 1903 | do | 102 | 94 | 280 | | do | | | do | |
| 2536 | do | do | E-5 | 1903 | do | 102 | 94 | 280 | | | | | do | |
| 2537 | Mrs. Wyatt | do | E-4 | 1896 | Bored, 2-inch | 112 | | 140 | 35 | Wind | 60.00 | | Domestic | |
| 2538 | T. A. House | San Antonio | E-4 | 1880? | Bored, 4-inch | 108 | 103 | 84 | 24 | Hand | 80.00 | | do | |
| 2539 | do | do | E-4,5 | 1880? | Bored, 6-inch | 106 | 105 | 260 | 27 | do | | | Stock | |
| 2540 | S. P. Walser | do | E-4 | 1903 | Bored, 5-inch | 108 | 102 | 127 | 24 | do | 121.00 | | Domestic | |
| 2541 | H. H. Davis | do | E, F-4 | 1880? | Bored, 4-inch | 112 | 105 | 76 | 27 | Wind | 60.00 | | do | |
| 2542 | John Grant | do | F-4 | 1885? | Bored, 3-inch | 113 | | 100 | 23 | Hand | | | Domestic; stock | |
| 2543 | J. A. Stewart | Santa Gertrudis | E, F-4 | 1884 | Bored, 4-inch | 108 | | 92 | 28 | Wind | 75.00 | | Domestic | |
| 2544 | J H. Fairbanks | do | F-5 | 1887 | do | 107 | 98 | 86 | 25 | do | 72.00 | | do | |
| 2545 | Robert Johnson | do | F-4 | 1888? | do | 108 | 101 | 84 | 25 | do | 68.00 | | do | |
| 2546 | B. M. Curtis | do | F-4 | 1901 | do | 109 | 101 | 80 | 28 | Hand | 65.00 | | do | |
| 2547 | do | do | F-4 | 1883 | Dug, 2½ by 2½ foot. | 109 | 101 | 10 | | do | | | Stock | |
| 2548 | O. T. Stroube | do | F-4 | 1904 | Bored, 12-inch | 112 | | 417 | 31 | Artesian ? | 800.00 | | Not used | |
| 2549 | Jim Wiley | do | F-4 | 1897 | Hydraulic, 2-inch | 111 | | 100 | 33 | Wind | 45.00 | | Domestic; stock | |
| 2550 | Mrs. Laubersheimer | do | F-4 | | Bored, 7-inch | 114 | 108 | 46 | 32 | Hand | | | Domestic | |
| 2551 | J. T. Barnett | do | F-4 | 1899 | Bored, 4-inch | 114 | | 80 | 31 | Wind | 65.00 | 45.00 | Stock; domestic | |
| 2552 | J. C. Simmons | do | F-4 | 1903 | do | 115 | 108 | 95 | 29 | Hand | 75.00 | | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2553 | Ida Maulhart | do | F-4 | 1897 | do | 120 | 113 | 87 | 26 | Wind | 68.00 | | do | | |
| 2554 | C. S. Williams | do | F, G-4 | 1898 | Bored, 2-inch | 122 | | 68 | 27 | do | 35.00 | | do | | |
| 2555 | Mrs. Jackson | do | G-4 | 1899 | Dug, 3 by 4 foot | 125 | 115 | 12 | 50 | Hand | | | do | | |
| 2556 | Barnett Bros | do | G-3 | 1897 | Bored, 2-inch | 124 | | 90 | 28 | do | 38.00 | | do | | |
| 2557 | H. H. Hunt | do | F, G-3 | 1896 | Hydraulic, 2-inch | 123 | | 75 | 30 | Wind | 30.00 | 40.00 | do | | |
| 2558 | Fred Wells | San Antonio | F-3 | | Dug, 2½ by 2½ foot | 122 | 118 | 9 | 61 | Hand | | | do | | |
| 2559 | Y. Rhodes | do | F-3 | 1883 | Dug | 122 | 117 | 7 | 34 | do | | | do | | |
| 2560 | M. Paxton | do | F-3 | 1893 | Driven, 1½-inch | 123 | | 17 | 37 | do | | | do | | |
| 2561 | J. S. Perry | do | F-3 | 1898 | Bored, 2-inch | 122 | | 80 | 23 | do | 40.00 | | Domestic; stock | | |
| 2562 | J. Solomon | do | F-3 | 1888? | Bored, 4-inch | 122 | | 100 | 24 | do | | | Domestic | | |
| 2563 | Wm. Harper | do | F-3 | 1899 | Bored, 12-inch | 120 | 114 | 130 | | Gas | 250.00 | 800.00 | Irrigation | | †75 |
| 2564 | do | do | F-4 | 1895? | Bored, 2-inch | 118 | | 106 | 24 | Wind | | | Domestic | | |
| 2565 | R. B. Harper | do | F-4 | 1899 | Bored, 4-inch | 117 | 109 | 104 | 23 | do | 90.00 | | Domestic; stock | | |
| 2566 | Grant Bros | do | E-4 | 1895 | do | 116 | 110 | 96 | 22 | Hand | | | Domestic | | |
| 2567 | T. N. Ellis | do | E-3 | 1878? | Bored, 7-inch | 120 | | 335 | 24 | Wind | | | do | | |
| 2568 | N. E. Fay | do | E-3 | 1875? | Bored, 6-inch | 122 | | 180 | 34 | do | | | do | | |
| 2569 | do | do | E-3 | 1903 | Bored, 10-inch | 124 | 118 | 221 | | Steam | 400.00 | | Irrigation | | †80 |
| 2570 | A. Leach | do | E-3 | 1902 | Bored, 5-inch | 122 | 116 | 101 | 29 | Hand | 91.00 | | Domestic; stock | | |
| 2571 | San Antonio School | do | E-3, 4 | | Bored, 7-inch | 121 | 119 | 35 | 31 | do | | | Domestic | | |
| 2572 | H. G. Hamilton | do | E-4 | 1892? | Bored, 2-inch | 121 | | 285 | 34 | do | | | do | | |
| 2573 | do | do | E-4 | 1903 | Bored, 5-inch | 121 | 118 | 360 | 35 | | | | Not used | | |
| 2574 | J. Clements | do | E-4 | 1888 | do | 120 | | 100 | 37 | Hand | 90.00 | | Domestic | | |
| 2575 | Lewis Gross | do | D-4 | 1904 | Bored, 12-inch | 118 | 112 | 185 | 71 | Not installed | 370.00 | | Irrigation | | |
| 2576 | do | do | E-4 | 1901 | Bored, 2-inch | 118 | | 127 | 36 | Hand | 55.00 | | Domestic | | |
| 2577 | K. Mosbacher | do | E-4 | 1902 | do | 116 | | 145 | 37 | Wind | 74.00 | 35.00 | do | | |
| 2578 | D. Barberena | do | E-3 | 1883 | Bored, 4-inch | 121 | 114 | 44 | 46 | Hand | | | do | | |
| 2579 | M. M. Shirley | do | F-3 | 1880 | do | 123 | 116 | 52 | 27 | do | 68.00 | | do | | |
| 2580 | Z. B. Slater | do | F-3 | 1880? | do | 124 | | 62 | 32 | Wind | | | do | | |
| 2581 | T. H. Stafford | do | F-3 | 1899 | Bored, 7-inch | 124 | 116 | 64 | 26 | do | 85.00 | | do | | |
| 2582 | Wm. Specht | do | F-2 | 1893 | do | 135 | 125 | 99 | 28 | do | 100.00 | 150.00 | do | | |
| 2583 | do | do | F-2 | 1883 | Dug, 3 by 4 foot | 132 | 123 | 15 | 48 | Hand | | | do | | |
| 2584 | do | do | E-2 | 1899 | Bored, 10-inch | 130 | 125 | 200 | 36 | | 250.00 | | Not used | | |
| 2585 | do | do | E-2 | 1899 | do | 130 | 128 | 860 | 38 | Gas | 3,000.00 | 950.00 | Irrigation | | †90 |
| 2586 | H. T. Shirley | do | E-2 | 1900 | Bored, 2-inch | 133 | | 230 | 37 | Wind | 110.00 | 40.00 | Domestic; stock | | |
| 2587 | L. A. Walker | do | E-2 | 1902 | Bored, 10-inch | 138 | 130 | 428 | 38 | Gas | 1,000.00 | | Irrigation | | †100 |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2588 | Robert Brown | San Antonio | D-2 | 1886? | Bored, 7-inch | 142 | | 320 | 36 | Wind | | | Domestic | |
| 2589 | W. Partridge | do | D, E-2 | 1898 | Bored, 2-inch | 139 | | 104 | 38 | do | $36.00 | | do | |
| 2590 | Doctor Royer | do | D-3 | 1903 | Bored, 10-inch | 137 | 128 | 103 | 37 | Gas | | | Irrigation | † 20 |
| 2591 | Mrs. Summers | do | D-2 | 1897? | Bored, 7-inch | 143 | 134 | 27 | | Wind | | | Domestic | |
| 2592 | W. J. Jones | do | D-2 | 1885? | Dug, 3 by 4 foot | 144 | 135 | 13 | 58 | Hand | | | Stock | |
| 2593 | C. Rathole | do | D-3 | 1882? | Bored, 7-inch | 139 | | 106 | 38 | Wind | 105.00 | $90.00 | Domestic; stock | |
| 2594 | Mrs. Baker | do | C-1 | | Dug, 4 by 4 foot | 176 | 158 | 19 | 56 | Hand | | | Domestic | |
| 2595 | do | do | C-1 | | Bored, 7-inch | 178 | | 60 | 53 | do | | | do | |
| 2596 | E. G. Greening | do | D-1 | | Dug, 2½ by 2½ foot | 175 | 157 | 19 | 86 | do | | | Stock; domestic | |
| 2597 | do | do | D-1 | 1899 | Bored, 10-inch | 163 | 153 | 181 | 39 | Electricity | 328.00 | | Irrigation | † 195 |
| 2598 | do | do | D-1 | 1896 | Bored, 4-inch | 150 | | 60 | 44 | Horsepower | | | Domestic; stock | |
| 2599 | do | do | D-2 | 1890? | Dug, 4 by 4 foot | 162 | 148 | 14 | 150 | Hand | | | Domestic | |
| 2600 | do | do | D-2 | 1901 | Bored, 4-inch | 150 | | 71 | 42 | do | 28.00 | | do | |
| 2601 | Mrs. Baker | do | D-2 | 1880? | Dug, 3 by 3 foot | 149 | 138 | 12 | 31 | do | | | do | |
| 2602 | Pacific Electric Co | do | F-2 | 1903 | Bored, 4-inch | 143 | | 90 | 28 | | | | do | |
| 2603 | Mrs. Baker | do | G-1, 2 | 1902 | Dug, 4 by 4 foot | 162 | 138 | 26 | 46 | Wind | | | Domestic; stock | |
| 2604 | do | do | F-1 | 1893 | do | 148 | 141 | 10 | 25 | do | | | Domestic | |
| 2605 | do | db | F-1 | 1876? | Bored, 6-inch | 146 | 142 | 510 | 52 | | | | Stock | † 2 |
| 2606 | do | do | F-1 | 1900 | Bored, 10-inch | 149 | 142 | 600 + | 52 | Gas | | | | † 10 |
| 2607 | Thomas Hodgins | do | G-2 | 1903 | Bored, 7-inch | 155 | 130 | 121 | 32 | Wind | | | Domestic | |
| 2608 | H. T. Gage | do | G-3 | 1890? | do | 141 | | 150 | 29 | Gas | | | do | |
| 2609 | B. Mendia | do | F-2 | 1887 | Dug, 4 by 4 foot | 137 | 122 | 16 | 29 | Wind | | | do | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2610 | A. Ducos | do | F-2 | 1901 | Bored, 8-inch | 137 | | 30 | 43 | do | | | do |
| 2611 | C. S. Walton | do | F-2 | 1895 | Bored, 4-inch | 137 | | 63 | 34 | do | | | do |
| 2612 | P. Lugo | do | F-2 | 1897 | Dug, 3 by 3 foot | 127 | 138 | 11 | 61 | Hand | | | do |
| 2613 | F. N. Lugo | do | F-2 | 1875? | Dug, 2 by 2 foot | 136 | 124 | 13 | 53 | do | | | do |
| 2614 | H. Reich | do | F-2 | 1864? | Dug, 2 by 4 foot | 136 | 124 | 16 | 28 | Wind | | | Domestic; stock |
| 2615 | Chas. Dochtermann | do | F-2 | 1898 | Dug, 4 by 4 foot | 135 | 125 | 12 | 35 | Hand | | | do |
| 2616 | E. Peschkt | do | F, G-3 | 1893? | Bored, 7-inch | 131 | 121 | 92 | 21 | Wind | 150.00 | | Domestic |
| 2617 | S. C. Foster | do | G-3 | 1887 | Bored, 4-inch | 130 | 119 | 105 | 23 | do | 110.00 | | do |
| 2618 | Mrs. S. Foster | do | G-3 | 1901 | Driven, 1½-inch | 130 | | 18 | 49 | Hand | | | do |
| 2619 | A. T. Foster | do | G-3 | 1888 | Bored, 4-inch | 129 | | 120 | 26 | do | | | do |
| 2620 | S. J. Arey | Santa Gertrudis | G-3 | 1891 | Bored, 7-inch | 130 | 119 | 139 | 25 | Wind | | | do |
| 2621 | Geo. Tweedy | do | H-2 | 1885? | Bored, 4-inch | 154 | 140 | 58 | 29 | do | | | Domestic; stock |
| 2622 | G. W. McCampbell | do | H-2,3 | 1878 | do | 153 | 138 | 60 | 28 | do | | | Domestic |
| 2623 | A. A. Tweedy | do | H-2 | 1888? | Bored, 7-inch | 157 | | 73 | 32 | do | | | do |
| 2624 | E. W. Reider | do | H-3 | 1901 | Bored, 4-inch | 155 | | 90 | 29 | do | 100.00 | | do |
| 2625 | L. L. Bequett | do | H-2 | 1898 | Driven, 1½-inch | 157 | | 14 | 25 | Hand | | | Stock |
| 2626 | do | do | H-2,3 | 1868 | Bored, 4-inch | 157 | | 40 | 25 | do | | | Domestic |
| 2627 | Mrs. McFarland | do | H-3 | 1899 | do | 152 | | 80 | 26 | Wind | | | do |
| 2628 | do | do | H-3 | 1902 | Bored, 12-inch | 152 | 135 | 484 | 30 | | | | Not used |
| 2629 | S. G. Reynolds | do | H-3 | 1883? | Bored, 4-inch | 150 | | 84 | 35 | Wind | | | Domestic |
| 2630 | W. T. East | do | H-3 | 1880? | do | 148 | | 72 | 36 | do | 72.00 | | do |
| 2631 | Stanley & Tweedy | do | H-3 | 1880? | do | 148 | 133 | 67 | 27 | Hand | | | do |
| 2632 | A. D. Kellam | do | H-3 | 1902 | do | 150 | 134 | 78 | 24 | do | 38.00 | | do |
| 2633 | A. O. Kempher | do | H-3 | 1878? | Dug, 3 by 3 foot | 149 | 137 | 13 | 102 | do | | | do |
| 2634 | J. W. Cate | do | H-3 | 1903 | Bored, 4-inch | 147 | 134 | 72 | 35 | Gas | 48.00 | | Domestic; irrigation. |
| 2635 | A. D. Kellam | do | H-3 | 1898 | do | 149 | 136 | 60 | 25 | Wind | | | Domestic |
| 2636 | Mrs. E. Taylor | do | H-3 | 1901 | Bored, 5-inch | 150 | | 55 | 26 | do | 35.00 | | do |
| 2637 | do | do | H-3 | 1885 | Bored, 7-inch | 148 | 136 | 150 | 19? | | | | do |
| 2638 | S. K. Stamps | do | H-3 | 1903 | Bored, 5-inch | 148 | 136 | 55 | 40 | Hand | 50.00 | | Stock |
| 2639 | E. S. Johnston | do | H-3 | 1902 | do | 147 | | 57 | 30 | Wind | 50.00 | | Domestic |
| 2640 | S. C. Roney | do | H-3 | 1903 | do | 142 | | 51 | 35 | do | 44.80 | | Domestic; stock |
| 2641 | M. L. Bangle | do | H-3 | 1895 | Driven, 1½-inch | 144 | | 19 | 38 | Hand | | | Domestic |
| 2642 | A. Keltz | do | H-3 | 1896 | Bored, 3-inch | 143 | | 60 | 34 | do | 30.00 | | do |
| 2643 | do | do | H-3 | 1891 | Driven, 1½-inch | 143 | | 17 | 37 | do | | | Stock |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2644 | E. Collins | Santa Gertrudis | H-3 | 1879? | Bored, 4-inch | 143 | 133 | 80 | 26 | Wind | | | Domestic; stock | |
| 2645 | J. P Fleming | do | G, H-3 | 1887 | do | 142 | 131 | 73 | 35 | do | | | Domestic | |
| 2646 | Wm. Caruthers | do | G-3 | 1898 | Bored, 2-inch | 141 | | 73 | 32 | Hand | | | do | |
| 2647 | do | do | G-3 | 1898 | do | 140 | | 68 | 33 | do | | | do | |
| 2648 | D. Tweedy | do | G, H-3 | 1895? | Bored, 4-inch | 140 | 131 | 52 | 30 | Wind | | | do | |
| 2649 | O. Stanley | do | G-3 | 1883 | do | 138 | | 70 | 29 | do | | | do | |
| 2650 | J. J. Tweedy | do | G-3 | 1888? | do | 138 | 127 | 60 | 26 | do | | | do | |
| 2651 | A. L. Ball | do | G-3 | 1885 | Bored, 7-inch | 131 | 117 | 675 | | | | | Not used | |
| 2652 | do | do | G-3 | 1888 | Bored, 4-inch | 135 | | 85 | 27 | Wind | | | Domestic | |
| 2653 | J. P. Fleming | do | G-3 | 1898 | Driven, 1½-inch | 135 | | 14 | 48 | | | | Domestic; stock | |
| 2654 | A. W. Neighbors | do | G-4 | 1890? | Bored, 4-inch | 132 | | 85 | 27 | Wind | | | Domestic | |
| 2655 | C. B. Miller | do | G-4 | 1885? | Driven, 1½-inch | 131 | | 16 | 52 | Hand | | | do | |
| 2656 | J. W. Neighbors | do | G-4 | 1892 | do | 131 | | 17 | 39 | do | | | do | |
| 2657 | H. D. Talbert | do | G-4 | 1892? | Bored, 4-inch | 130 | | 85 | 28 | do | | | do | |
| 2658 | E. H. Henry | do | G-4 | 1888? | do | 128 | 118 | 20 | 42 | do | | | do | |
| 2659 | S. J. Williams | do | G-4 | 1896 | Driven, 1½-inch | 130 | | 16 | 62 | do | | | do | |
| 2660 | C. Corsen | do | G-4 | 1870? | Bored, 4-inch | 128 | 118 | 20 | 47 | do | | | do | |
| 2661 | A. W. Neighbors | do | G-4 | | do | 129 | 119 | 73 | 28 | do | | | do | |
| 2662 | Mrs. A. Cole | do | G-3, 4 | 1887? | do | 128 | | 93 | 33 | Wind | | | do | |
| 2663 | J. H. Burke | do | G-4 | 1875? | Bored, 7-inch | 128 | 117 | 96 | 27 | do | | | do | |
| 2664 | M. Bohen | do | G-4 | 1903 | Driven, 2-inch | 125 | | 14 | 40 | Hand | | | do | |
| 2665 | Frank Burke | do | G-4 | 1891 | Bored, 4-inch | 119 | | 84 | 28 | Wind | | | Domestic; stock | |
| 2666 | J. D. Ardis | do | F, G-4 | 1901 | Bored, 5-inch | 117 | 106 | 85 | 28 | Hand | $65.00 | | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2667 | C. A. McKnight | do | G-4 | 1897 | Bored, 1½-inch | 117 | | 15 | 34 | do | | | do | |
| 2668 | Mr. Suggs | do | G-4 | 1898 | Hydraulic, 2-inch | 116 | | 84 | 31 | do | 38.00 | | do | |
| 2669 | D. Bennett | do | G-5 | 1893? | Bored, 4-inch | 117 | | 93 | 30 | Wind | 70.00 | | do | |
| 2670 | J. Smith | do | G-4,5 | 1902 | do | 118 | 108 | 95 | 30 | Hand | | | do | |
| 2671 | J. C. Rives | do | G-4 | 1901 | Driven, 1¼-inch | 119 | | 15 | 34 | do | | | do | |
| 2672 | H. M. Blair | do | G-4 | 1899 | do | 120 | | 15 | 33 | do | | | do | |
| 2673 | J. C. Rives | do | G-4 | 1883? | Bored, 4-inch | 122 | 112 | 92 | 30 | Wind | | | Stock | |
| 2674 | H. G. Harper | do | G-4 | 1890? | do | 123 | 113 | 84 | 34 | do | 75.00 | | Domestic | |
| 2675 | G. F. Brownson | do | G-4 | 1880? | do | 125 | | 84 | 26 | Hand | 75.00 | | do | |
| 2676 | L. McLane | do | G-4 | 1898 | do | 127 | | 83 | 37 | do | 75.00 | | do | |
| 2677 | J. C. Simmons | do | G-4 | 1896? | do | 127 | | 90 | 29 | Wind | 80.00 | | Domestic; stock | |
| 2678 | Ella L. Squire | do | G-4 | 1898 | Bored, 2-inch | 130 | | 82 | 34 | do | 34.00 | | Domestic | |
| 2679 | Mr. Cohen | do | G-4 | 1875 | Bored, 4-inch | 131 | | 104 | 23 | do | | | Stock | |
| 2680 | A. S. Gray | do | H-4 | 1880 | do | 139 | | 110 | 29 | do | | | Domestic | |
| 2681 | A. Rubio | do | G-4 | 1903 | Bored, 9½-inch | 130 | 120 | 110 | | Not installed | 110.00 | | | |
| 2682 | do | do | G-4 | | Bored, 4-inch | 130 | | 80 | 31 | Wind | | | Domestic | |
| 2683 | Sam Frankel | do | G-4 | 1895 | Bored, 2-inch | 130 | | 48 | 30 | Hand | | | do | |
| 2684 | C. Nimmo | do | H-4 | | Bored, 4-inch | 128 | 115 | 72 | 56 | do | | | do | |
| 2685 | W. B. French | do | H-4 | 1901 | do | 131 | | 90 | 49 | do | 68.00 | | do | |
| 2686 | James Brookshire | do | H-4 | 1890 | do | 130 | 118 | 71 | 39 | Wind | 55.00 | | do | |
| 2687 | D. Woods | do | H-4 | 1885? | do | 130 | 11 | 75 | 37 | Hand | | | do | |
| 2688 | C. C. Lower | do | H-4 | 1890? | do | 127 | 115 | 85 | 34 | Wind | | | do | |
| 2689 | James W. Rugg | do | H-4 | 1896 | Bored, 2-inch | 127 | | 78 | 29 | do | 35.00 | | do | |
| 2690 | A. L. Ball | do | H-4 | 1886 | Bored, 4-inch | 126 | 113 | 72 | 32 | do | | | do | |
| 2691 | J. B. Graham | do | G-4 | 1883? | do | 127 | | 84 | 31 | do | | | do | |
| 2693 | A. Thompson | do | G-4 | | do | 123 | | 85 | 32 | do | | | do | |
| 2694 | Mrs. A. C. Smith | do | G-4 | 1878 | do | 123 | 111 | 75 | 32 | do | | | do | |
| 2695 | I. M. Cochran | do | G-4 | 1880? | Bored, 7-inch | 123 | 110 | 98 | 29 | do | | | do | |
| 2697 | John Strine | do | G-4 | 1903 | Bored, 4-inch | 121 | | 85 | 32 | do | 73.10 | | do | |
| 2698 | Doctor Rowley | do | G-4,5 | 1873 | Bored, 7-inch | 120 | | 80 | 30 | do | | | do | |
| 2699 | Christian Church | do | G-5 | 1903 | Bored, 4-inch | 119 | | 97 | 31 | Hand | 73.00 | | do | |
| 2700 | E. J. Easterly | do | G-5 | 1889? | Bored, 5-inch | 118 | | 100 | 31 | Wind | | | do | |
| 2701 | Mrs. J. Harris | do | G-5 | 1885 | Bored, 4-inch | 119 | | 88 | 41 | do | | | do | |
| 2702 | Mrs. M. E. Frankel | do | G-5 | 1903 | Bored, 5-inch | 119 | 111 | 86 | 36 | Hand | 80.00 | | do | |
| 2703 | B. F. Witherspoon | do | G-5 | 1887 | Bored, 4-inch | 118 | 108 | 70 | 34 | do | 60.00 | | do | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2704 | W. H. Steel | Santa Gertrudis | G-5 | 1903 | Bored, 4-inch | 118 | 108 | 90 | 30 | Hand | $76.50 | | Domestic | |
| 2705 | Mrs. E. F. Scribner | do | G-5 | 1893 | do | 118 | 108 | 68 | 33 | do | 55.00 | | do | |
| 2706 | H. A. Adams | do | G-5 | 1902 | Bored, 5-inch | 118 | 109 | 83 | 32 | do | 72.25 | | do | |
| 2707 | W. E. White | do | G-5 | | Bored, 7-inch | 119 | 108 | 70 | 32 | do | | | do | |
| 2708 | Mrs. J. M. Smith | do | G-5 | 1901 | Bored, 4-inch | 119 | 108 | 91 | 34 | do | 75.00 | | do | |
| 2709 | Doctor Haygood | do | G-5 | | do | 120 | 109 | 85 | 32 | Wind | | | do | |
| 2710 | S. K. Woodward | do | G-4 | 1885? | do | 121 | 111 | 75 | 30 | do | | | do | |
| 2711 | Dr. J. H. Reed | do | G-4 | 1898 | do | 122 | 110 | 84 | 29 | do | 70.00 | | do | |
| 2712 | S. Cohen | do | G-5 | 1884 | do | 121 | 110 | 96 | 29 | do | 65.00 | | do | |
| 2713 | D. P. Smart | do | G-5 | 1901 | Bored, 5-inch | 119 | | 90 | 30 | Gas | 85.00 | | do | |
| 2714 | J. H. McCullough | do | G-5 | 1903 | do | 120 | 110 | 90 | 30 | do | 80.00 | | Domestic; irrigation. | |
| 2715 | Mrs. R. Steinart | do | G-5 | 1894 | Bored, 4-inch | 118 | | 88 | 30 | Wind | 60.00 | | Domestic | |
| 2716 | D. P. Smart | do | G-5 | 1903 | Bored, 5-inch | 118 | 108 | 80 | 39 | do | 75.00 | | do | |
| 2717 | Geo. Elliott | do | G-5 | 1903 | do | 119 | 109 | 87 | 30 | Hand | 79.00 | | do | |
| 2718 | Mrs. M. E. Frankel | do | G-5 | 1901 | do | 120 | 110 | 62 | 33 | do | 65.00 | | do | |
| 2719 | James Booker | do | G-5 | 1885? | Bored, 7-inch | 120 | 110 | 73 | 28 | Wind | | | do | |
| 2720 | J. C. Stout | do | G-5 | 1903 | Bored, 5-inch | 121 | 111 | 87 | 40 | do | 70.00 | $57.00 | Domestic; stock | |
| 2721 | T. R. Crawford | do | G-5 | 1896? | Bored, 10-inch | 119 | 108 | 86 | 36 | Gas, wind | | | Domestic; irrigation. | |
| 2722 | Joe Wegerer | do | G-5 | 1880? | Bored, 7-inch | 120 | 109 | 84 | 45 | Wind, hand | | | Domestic | |
| 2723 | D. J. Marr | do | G-5 | | Dug, 2 by 2 foot | 119 | 114 | 9 | 49 | Hand | | | do | |
| 2724 | do | do | G-5 | 1903 | Bored, 5-inch | 119 | 110 | 72 | 40 | do | 65.00 | | Stock | |
| 2725 | Miss M. Kellar | do | G-5 | 1880? | Bored, 4-inch | 120 | 108 | 78 | 33 | do | | | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2726 | L. Saalfeldt | do | G-5 | 1880? | do | 119 | 110 | 54 | 38 | do | | | do | |
| 2727 | J. E. Jenison | do | H-5 | 1903 | do | 119 | 109 | 69 | 31 | do | 45.00 | | do | |
| 2728 | T. F. Renfro | do | H-5 | | do | 118 | 102 | 55 | 31 | do | | | do | |
| 2729 | J. E. Jenison | do | H-5 | 1899 | do | 118 | | 63 | 31 | Wind | 40.00 | | do | |
| 2730 | do | do | H-5 | 1890 | do | 118 | | 55 | 40 | do | 30.00 | | do | |
| 2731 | A. Anderson | do | H-5 | 1895 | Hydraulic, 2-inch | 117 | | 75 | 41 | do | 35.00 | | do | |
| 2732 | R. T. Newcomb | do | H-5 | 1903 | do | 116 | | 80 | 51 | Hand | 36.00 | | do | |
| 2733 | do | do | H-5 | 1870 | Dug, 3 by 3 foot | 116 | 108 | 13 | 56 | do | | | Domestic; stock | |
| 2734 | J. W. Pangborn | do | H-5 | 1902 | Bored, 5-inch | 113 | 106 | 52 | 48 | do | 44.00 | | do | |
| 2735 | Chas. Harding | do | H-5 | 1903 | do | 112 | 105 | 55 | 43 | do | 58.00 | | Domestic | |
| 2736 | Mrs. Clearwater | do | H-5,6 | 1902? | do | 111 | 102 | 68 | 49 | do | 63.00 | | do | |
| 2737 | C. C. Francis | do | H-5 | 1894? | Bored, 4-inch | 111 | | 60 | 56 | Wind | | | Domestic; stock | |
| 2738 | John W Rudd | do | H-5 | 1900 | do | 115 | | 56 | 28 | do | 43.00 | | do | |
| 2739 | J. W. Ragland | do | H-5 | 1888 | Dug, 3 by 3 foot | 119 | 108 | 16 | 61 | Hand | | | do | |
| 2740 | H. M. Conch | do | H-5 | 1903 | Bored, 5-inch | 120 | 110 | 58 | 107 | do | 53.00 | | Domestic | |
| 2741 | Roy Jenison | do | H-5 | 1897 | Bored, 2-inch | 125 | | 65 | 52 | Wind | | | do | |
| 2742 | J. E. Jenison | do | H-5 | 1873 | Bored, 7-inch | 125 | 115 | 380 | 28 | do | | | do | |
| 2743 | E. J. Standlee | do | H-5 | 1870? | do | 128 | 114 | 71 | 44 | do | | | Stock | |
| 2744 | do | do | H-4 | 1900 | Bored, 4-inch | 129 | | 66 | 39 | do | 60.00 | | Domestic | |
| 2745 | Frank Morrison | do | I-4,5 | 1897 | do | 126 | 115 | 55 | 53 | Hand | 30.00 | | do | |
| 2746 | R. W. Wright | do | I-4,5 | 1899 | do | 123 | 110 | 46 | 30 | do | 32.00 | | do | |
| 2747 | H. S. Redfield | do | I-4 | 1901 | do | 127 | | 58 | 44 | Wind | 50.00 | 40.00 | Domestic; stock | |
| 2748 | Wm. Campbell | do | H, I-4 | 1903 | Bored, 5-inch | 131 | | 68 | 51 | Hand | 62.50 | | Domestic | |
| 2749 | W Morrison | do | H-4,5 | | Bored, 4-inch | 128 | | 65 | 45 | do | | | do | |
| 2750 | J. M. Mayes | do | H-4 | 1898 | do | 131 | | 68 | 57 | Wind | 45.00 | | do | |
| 2751 | W. D. Mansfield | do | H-4 | 1893 | Bored, 2-inch | 132 | | 58 | 46 | Hand | 35.00 | | do | |
| 2752 | S. A. Wilks | do | H-4 | 1898 | Bored, 4-inch | 133 | 122 | 56 | 53 | do | | | do | |
| 2753 | J. Edmondson | do | H-4 | 1891? | Bored, 7-inch | 131 | 101 | 140 | 24 | Wind | | | do | |
| 2754 | J. A. Smith | do | H-4 | 1903 | Bored, 4-inch | 130 | 120 | 70 | 56 | Hand | 60.00 | | do | |
| 2755 | John Bartlett | do | H-4 | 1891? | do | 130 | | 72 | 42 | do | 50.00 | | do | |
| 2756 | R. S. Mayes | do | H-4 | 1880? | do | 131 | 120 | 70 | 37 | Wind | 46.00 | | Domestic; stock | |
| 2757 | Wm. Sex | do | H-4 | 1891 | Driven, 1½-inch | 132 | | 12 | | Hand | | | do | |
| 2758 | H. Griffith | do | H-4 | 1890 | Bored, 4-inch | 134 | | 76 | 31 | Wind | 65.00 | | Domestic | |
| 2759 | do | do | H-4 | 1903 | Bored, 5-inch | 134 | 123 | 60 | 34 | do | 75.00 | | Domestic; stock | |
| 2760 | do | do | H-4 | 1903 | Bored, 12-inch | 137 | 126 | 180 | | Gas | | | Irrigation | †100 |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2761 | Mr. Carruthers | Santa Gertrudis | H-4 | 1885? | Bored, 4-inch | 137 | 128 | 83 | 30 | Hand | | | Domestic | |
| 2762 | Galltoin School | do | H-4 | 1895 | do | 138 | | 80 | 28 | do | | | do | |
| 2763 | J. E. Walton | do | H-4 | 1891? | do | 138 | 128 | 52 | 26 | do | | | do | |
| 2764 | E. F. Trabant | do | H-4 | 1890? | do | 142 | 128 | 59 | 42 | do | | | do | |
| 2765 | Mrs. A. Hagan | do | H-3,4 | 1892? | do | 143 | | 62 | 35 | Wind | | | do | |
| 2766 | Mr. Stephenson | do | H-4 | | do | 140 | | 80 | 40 | Hand | | | do | |
| 2767 | Wm. Morrow | do | H-4 | 1895 | do | 138 | | 78 | 49 | do | | | do | |
| 2768 | John Nelson | do | H-4 | 1897 | do | 139 | 127 | 64 | 37 | Wind | $40.00 | | do | |
| 2769 | Wm. Sex | do | H-4 | 1895 | do | 137 | | 100 | | do | 70.00 | | do | |
| 2770 | C. W. Nelson | do | H-4 | 1895 | Dug, 4 by 4 foot | 138 | 126 | 15 | 68 | do | | | Domestic; stock | |
| 2771 | Walter Grace | do | H-4 | 1901 | Bored, 4-inch | 137 | | 70 | 69 | do | 29.00+ | $40.00 | Domestic | |
| 2772 | D. F. Conant | do | I-4 | | do | 133 | | 78 | 42 | do | | | do | |
| 2773 | H. W. Kenney | do | I-4 | 1887? | Bored, 2-inch | 132 | | 80 | 38 | Hand | | | do | |
| 2774 | R. S. Davis | do | I-4 | 1900 | Bored, 4-inch | 129 | | 68 | 33 | Wind | 51.00 | 35.00 | do | |
| 2775 | W. M. Ramp | do | I-4 | 1887 | do | 130 | | 56 | 27 | do | 35.00 | | do | |
| 2776 | Mrs. M. Van Deusen | do | I-4 | 1885? | do | 132 | 124 | 49 | 53 | Hand | 49.00 | | do | |
| 2777 | T. Van Deusen | do | I-4 | 1901 | do | 133 | | 50 | 58 | Gas, wind | 42.00 | 155.00 | Domestic; irrigation. | |
| 2778 | J. S. Williams | do | I-4 | 1884? | do | 134 | | 58 | 32 | Wind | | | Domestic | |
| 2779 | Peter Ralph | do | I-4 | 1893 | Driven, 1½-inch | 135 | | 26 | 59 | Hand | | | do | |
| 2780 | P. R. Ralph | do | I-4 | 1890? | Bored, 4-inch | 136 | | 58 | 34 | do | 35.00 | | do | |
| 2781 | H. H. Mills | do | I-4 | 1898? | do | 138 | | 58 | 42 | Wind | | | Domestic; stock | |
| 2782 | L. R. Paxton | do | I-4 | 1901 | do | 140 | | 63 | 24 | do | 50.00 | 35.00 | Stock | |
| 2783 | H. E. Jamieson | do | I-4 | 1865? | Bored, 7-inch | 141 | | 31 | 35 | Hand | | | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2784 | Mr. Crawford | do | I-4 | 1900 | Hydraulic, 2-inch. | 140 | | 65 | 30 | do | 35.00 | | do | | |
| 2785 | G. S. Beckwith | do | I-4 | 1895 | Dug, 4 by 4 foot | 140 | 124 | 18 | 77 | do | | | do | | |
| 2786 | J. J. King | do | I-4 | 1888? | Bored, 4-inch | 141 | | 62 | 30 | Wind | | | do | | |
| 2787 | C. Vulgamott | do | I-4 | 1889? | Bored, 7-inch | 142 | | 65 | 29 | do | | | do | | |
| 2788 | James Stewart | do | I-3,4 | 1888 | Bored, 4-inch | 142 | 126 | 70 | 34 | do | 55.00 | | Domestic; stock | | |
| 2789 | Wedemeyer estate | do | I-4 | 1896? | Hydraulic, 2-inch. | 138 | | 53 | 35 | Hand? | 40.00 | | Stock; domestic | | |
| 2790 | E. R. Wylie | do | I-4 | 1888? | Bored, 4-inch | 144 | | 69 | 34 | Wind | 52.00 | | Domestic | | |
| 2791 | E. Clay | do | H,I-3 | 1890? | do | 145 | 136 | 49 | 31 | Hand | | | do | | |
| 2792 | do | do | I-3 | | Dug, 3 by 3 foot | 146 | 137 | 10 | 46 | do | | | do | | |
| 2793 | D. Standlee | do | H-3 | 1903 | Bored, 5-inch | 146 | 136 | 70 | 34 | Wind | 60.00 | | do | | |
| 2794 | O. Burke | do | I-3 | 1889? | Bored, 7-inch | 145 | | 80 | 33 | do | 100.00 | | do | | |
| 2795 | Dr. J. Allen Osmun | do | I-3 | 1903 | Bored, 5-inch | 150 | 135 | 62 | | Gas, wind | 55.80 | 250.00 | Domestic; stock | | |
| 2796 | do | do | I-3 | 1903 | Bored, 4-inch | 155 | | 64 | 28 | Wind, gas | 60.00 | | do | | |
| 2797 | E. H. Root | do | I-3 | 1903 | Bored, 5-inch | 155 | | 62 | 25 | Hand | 46.00 | | Domestic | | |
| 2798 | H. Sarrasin | do | I-3 | 1890 | Bored, 4-inch | 151 | 136 | 69 | 31 | Wind | 55.00 | | Domestic; stock | | |
| 2799 | S. B. Root | do | I-3 | 1901 | do | 152 | 136 | 63 | 41 | do | 47.50 | 35.00 | Domestic | | |
| 2800 | J. A. Shade | do | I-3 | 1898 | Bored, 7-inch | 152 | | 78 | 33 | do | | | do | | |
| 2801 | Mr. Wood | do | I-3 | 1900 | Bored, 5-inch | 152 | 137 | 56 | 33 | do | 50.00 | | do | | |
| 2802 | J. G. B. Haynes | do | I-3 | 1891 | Bored, 4-inch | 148 | 136 | 56 | 34 | Hand | 75.00 | | do | | |
| 2803 | do | do | I-3 | 1897 | Bored, 7-inch | 147 | 136 | 40 | 31 | do | 65.00 | | do | | |
| 2804 | F. E. Welsh | do | I-3 | 1895 | Bored, 2-inch | 145 | | 40 | 24 | Wind | 22.00 | 35.00 | do | | |
| 2805 | W. H. Davis | do | I-3 | 1901 | Bored, 4-inch | 146 | | 60 | 36 | do | | | do | | |
| 2806 | John Carden | do | I-3 | | do | 143 | 130 | 41 | 33 | Hand | | | do | | |
| 2807 | Miss H. Clark | do | I-3 | 1889? | Bored, 7-inch | 144 | 129 | 34 | 36 | do | | | do | | |
| 2808 | C. Leopold | do | I-3 | 1898 | Bored, 4-inch | 141 | | 30 | 39 | Wind | | | do | | |
| 2809 | E. & J. Cockrell | do | I-3,4 | 1897 | do | 139 | | 40 | 34 | do | | | do | | |
| 2810 | W. Gould | do | I-3 | 1882? | do | 141 | 119 | 50 | 22 | Hand, wind | | | do | | |
| 2811 | F. C. Harvey | do | I-4 | 1890? | do | 139 | 122 | 54 | 34 | Wind | 40.00 | | do | | |
| 2812 | J. H. Burke | do | I-3 | 1897 | do | 155 | | 74 | 32 | do | 55.00 | | do | | |
| 2813 | do | do | I-3 | 1884 | Bored, 7-inch | 155 | | 84 | 32 | do | 110.00 | | do | | |
| 2814 | R. H. Reynolds | do | I-3 | 1901 | Driven, 1¼-inch | 157 | | 18 | 57 | do | | | Domestic; stock | | |
| 2815 | H. L. Montgomery | do | I-3 | 1892? | Bored, 4-inch | 157 | 144 | 57 | 45 | do | 38.00 | | Domestic | | |
| 2816 | A. A. White | do | I-3 | 1893 | do | 157 | | 70 | 40 | do | 45.00 | | do | | |
| 2817 | Rivera School | do | I-3 | 1895 | do | 160 | 145 | 45 | 23 | Hand | | | do | | |
| 2819 | J. A. Garrison | do | I-3 | 1889 | do | 159 | 146 | 70 | 33 | Wind | 45.00 | | do | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2819 | J. A. Garrison | Santa Gertrudis | I-3 | 1899 | Bored, 2-inch | 159 | | 38 | 53 | Wind | $20.00 | $37.00 | Domestic | |
| 2820 | D. H. Montgomery | do | I-3 | 1890? | Bored, 4-inch | 159 | 146 | 65 | 37 | Hand | 40.00 | | do | |
| 2821 | H. S. Welsh | do | I-3 | 1902 | do | 159 | 146 | 67 | 37 | do | 56.00 | | do | |
| 2822 | H. H. West | do | I-3 | 1889? | do | 160 | 146 | 60 | 37 | Wind | | | do | |
| 2823 | Mrs. Sidwell | do | I-3 | 1900 | do | 160 | | 68 | 33 | do | 52.00 | | do | |
| 2824 | S. B. Guthrie | do | I-3 | 1901 | do | 161 | | 62 | 32 | do | 52.00 | | do | |
| 2825 | S. W. Burke | do | I-3 | 1888? | do | 160 | | 64 | 31 | Hand | 48.00 | | do | |
| 2826 | J. L. Groton | do | I-3 | 1899 | do | 160 | 147 | 58 | 32 | do | 48.00 | | do | |
| 2827 | Pallett & Graham | do | I-3 | 1903 | do | 161 | 148 | 63 | 42 | Wind | 48.00 | | Domestic; stock | |
| 2828 | F. Garrison | do | I-3 | 1887? | Driven, 1½-inch | 160 | | 19 | 51 | do | 8.00 | | Domestic | |
| 2829 | E. F. Bryant | do | I-2,3 | 1890? | Bored, 4-inch | 160 | 149 | 42 | | Hand | 48.00 | | Domestic; stock | |
| 2830 | M. S. Smith | do | I-3 | 1901 | do | 162 | | 63 | 37 | do | 50.00 | | Domestic | |
| 2831 | F. M. Odell | do | I-2 | 1903 | do | 163 | 151 | 63 | 35 | do | 46.00 | | do | |
| 2832 | C. B. Bullock | do | I-3 | 1899? | do | 157 | | 80 | 31 | Wind | 60.00 | | do | |
| 2833 | O. P. Passon | do | I-3 | 1888? | Bored, 7-inch | 156 | 142 | 77 | | do | 100.00 | | do | |
| 2834 | Geo. Bullock | Paso de Bartolo | I-3 | 1902 | Bored, 5-inch | 157 | | 57 | 32 | do | 60.00 | | do | |
| 2835 | J. A. Perkins | do | I-2,3 | 1899 | Bored, 4-inch | 159 | 145 | 70 | 35 | do | 55.00 | | do | |
| 2836 | T. B. Chapman | do | I-2 | 1892? | Bored, 7-inch | 161 | 148 | 71 | 31 | do | 95.00 | | do | |
| 2837 | T. R. Passons | do | I-2 | 1888 | Bored, 4-inch | 162 | | 87 | 33 | do | 68.00 | | do | |
| 2838 | H. M. Moss | do | I-2 | 1886? | do | 164 | | 68 | 33 | do | | | do | |
| 2839 | B. P. Passons | do | I-2 | 1903 | do | 163 | 153 | 57 | 39 | do | 43.00 | 35.00 | do | |
| 2840 | C. S. Gilman | do | I-2 | 1902 | Driven, 1½-inch | 162 | | 18 | 29 | do | 7.00 | 35.00 | do | |
| 2841 | G. W. Scott | do | I-2 | 1890 | do | 161 | | 18 | 47 | do | | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2842 | W. L. Borden | do | I-2 | 1899 | do | 163 | | 16 | 25 | do | | 30.00 | do | | |
| 2843 | V. H. Furnier | do | I-2 | 1900 | do | 166 | | 20 | 22 | Hand | | | do | | |
| 2844 | McDonald Bros | do | I-2 | 1893 | Bored, 4-inch | 169 | 152 | 51 | 23 | do | | 40.00 | Domestic; stock | | |
| 2845 | W. Hadley | do | I-2 | 1883? | Bored, 7-inch | 168 | 152 | 22 | 33 | do | | | Domestic | | |
| 2846 | do | do | I-2 | 1899? | Driven, 1½-inch | 167 | | 16 | 35 | do | | | do | | |
| 2847 | H. L. Montgomery | do | I-1 | 1879? | Bored, 7-inch | 166 | | 49 | 37 | Wind | | | Domestic; stock | | |
| 2848 | W. Hadley | do | I-2 | 1899 | Driven, 1½-inch | 165 | | 17 | 30 | Hand | | | Domestic | | |
| 2849 | H. White | do | I-2 | 1900 | do | 171 | | 19 | 44 | do | | | do | | |
| 2850 | H. S. White | do | I-2 | 1900 | Bored, 4-inch | 171 | 156 | 40 | 26 | Wind | | 30.00 | do | | |
| 2851 | T. L. Gooch | do | I-2 | 1903 | do | 171 | | 48 | 29 | Hand | | 42.00 | do | | |
| 2852 | Henry White | do | I-2 | 1886 | do | 173 | | 30 | 26 | do | | 30.00 | do | | |
| 2853 | E. C. Coffman | do | I-1 | 1898 | Hydraulic, 2-inch | 173 | | 30 | | Gas? | | 21.00 | do | | |
| 2854 | B. C. Coffman | do | I-1 | 1885? | Bored, 4-inch | 173 | 154 | 40 | 31 | Wind | | | Domestic; stock | | |
| 2855 | J. J. Nagle | do | I-1 | 1890? | do | 176 | 158 | 63 | 30 | do | | 50.00 | Domestic | | |
| 2856 | J. Carden | do | J-1 | | Bored, 1½-inch | 180 | | 20 | 38 | do | | | do | | |
| 2857 | W. L. Witherow | do | J-1 | 1879? | do | 181 | | 20 | 33 | do | | | Domestic; stock | | |
| 2858 | J. Barlow | do | I-1 | 1882 | Bored, 7-inch | 179 | 161 | 48 | 29 | do | | | Domestic | | |
| 2859 | W. L. Sidwell | do | J-1 | 1896 | Bored, 4-inch | 180 | 162 | 40 | 28 | do | | 35.00 | do | | |
| 2860 | J. L. Hooper | do | J-1 | 1902 | do | 185 | 167 | 60 | 26 | do | | 45.00 | do | | |
| 2861 | J. P. McGill | do | J-1 | 1897 | Hydraulic, 2-inch | 185 | | 48 | 29 | do | | 30.00 | do | | |
| 2862 | Mr. Everett | do | J-1 | | Dug, 2 by 3 foot | 188 | 173 | 16 | 41 | Hand | | | Stock | | |
| 2863 | F. A. Coffman | do | | 1898 | Hydraulic, 2-inch | 188 | | 29 | 24 | Wind | | 21.00 | Domestic | | |
| 2864 | Fred Layman | do | J-1 | 1902 | Bored, 5-inch | 188 | | 52 | 24 | do | | 48.00 | do | | |
| 2865 | John M. Chassee | do | J-1 | 1895 | Dug, 2 by 3 foot | 190 | 175 | 16 | 35 | Hand | | | do | | |
| 2866 | John T. Jones | do | J-1 | 1896? | Bored, 4-inch | 186 | 169 | 34 | 36 | do | | | do | | |
| 2867 | E. Gurada | do | J-1 | | Bored, 7-inch | 180 | 170 | 41 | 26 | Wind | | | do | | |
| 2868 | Ranchito School | do | J-1 | 1876 | Bored, 4-inch | 182 | | 50 | 29 | do | | 30.00 | do | | |
| 2869 | Albert Duffill | do | J-1 | 1893 | Bored, 7-inch | 179 | 160 | 84 | 28 | do | | | Domestic; stock | | |
| 2870 | B. M. Hotchkiss | do | J-1 | 1890 | Bored, 4-inch | 180 | 163 | 87 | 31 | do | | | Domestic | | |
| 2871 | J. L. Spencer | do | J-1 | 1900 | do | 179 | | 45 | 33 | do | | 35.00 | do | | |
| 2872 | P. A. McGaugh | do | J-1 | 1901 | do | 178 | 161 | 35 | 31 | do | | 30.00 | do | | |
| 2873 | J. Dunlap | do | J-1 | 1879? | Bored, 7-inch | 172 | 156 | 50 | 33 | do | | | do | | |
| 2874 | P. G. McGaugh | do | J-1 | 1890 | Bored, 4-inch | 174 | 157 | 35 | 40 | Hand | | 30.00 | do | | |
| 2875 | Theodore Johnson | do | J-1 | 1888 | do | 174 | 157 | 45 | 32 | do | | | do | | |
| 2876 | do | do | J-1 | 1890? | do | 174 | 157 | 45 | 31 | do | | | Stock | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2877 | Tracy Abbott | Paso de Bartolo | J-1,2 | 1892? | Bored, 4-inch | 172 | | 50 | 29 | Wind | | | Domestic | |
| 2878 | W. P. Story | do | J-2 | 1893 | do | 172 | | 49 | 37 | do | $37.00 | | do | |
| 2879 | T. E. Newlin | do | J-2 | | do | 174 | 158 | 48? | 31 | do | | | do | |
| 2880 | T. L. Gooch | do | I-2 | 1878 | Bored, 7-inch | 172 | 156 | 48 | 40 | do | 52.00 | | do | |
| 2881 | Mrs. A. Lynch | do | I,J-2 | 1887 | do | 169 | | 58 | 33 | do | 58.00 | | Domestic; stock | |
| 2882 | R. Stroud | do | J-2 | 1903 | Bored, 5-inch | 165 | | 51 | 31 | do | 43.50 | | Domestic | |
| 2883 | J. A. Montgomery | do | I-2 | 1898 | Bored, 4-inch | 168 | | 60 | 30 | do | 46.00 | | do | |
| 2884 | T. L. Gooch | do | I-2 | 1886 | do | 167 | 153 | 62 | | do | 55.00 | | Stock | |
| 2885 | T. P. McLane | do | I-2 | 1903 | Bored, 5-inch | 166 | | 61 | 39 | Hand | 57.70 | | Domestic | |
| 2886 | J. O. Castell | Santa Gertrudis | I-3 | 1902 | Dug, 3 by 3 foot | 144 | 137 | 9 | 32 | do | | | do | |
| 2887 | Frank Bonchard | do | J-3 | 1902 | Bored, 4-inch | 159 | 144 | 70 | 32 | Wind | 52.00 | | Domestic; stock | |
| 2888 | C. J. Gish | Paso de Bartolo | J-3 | 1901 | Bored, 5-inch | 157 | 147 | 44 | 35 | Hand | 39.00 | | Domestic | |
| 2889 | do | do | J-3 | 1901 | do | 158 | 147 | 89 | 33 | do | 35.00 | | Stock | |
| 2890 | F. Bonchard | do | J-3 | 1897? | Bored, 2-inch | 158 | | 68 | 31 | Wind | 38.50 | | Domestic | |
| 2891 | John Seppi | do | J-3 | 1903 | Bored, 5-inch | 159 | 146 | 58 | 34 | do | 52.00 | | do | |
| 2892 | J. A. Cover | do | J-3 | 1896 | Bored, 2-inch | 155 | | 63 | 29 | Hand | 31.00 | | do | |
| 2893 | M. J. Brooks | do | J-3 | 1896 | do | 154 | | 60 | 32 | Wind | 26.00 | $45.00 | do | |
| 2894 | H. Miller | do | J-3 | 1900 | Bored, 4-inch | 151 | 143 | 51 | | Hand | | | do | |
| 2895 | Aaron Miller | do | J-3 | 1901 | Bored, 7-inch | 153 | 142 | 60 | 33 | Wind | | | Domestic; stock | |
| 2896 | M. L. Kendal | do | J-3 | 1895 | Bored, 5-inch | 151 | 141 | 60 | 32 | Hand | 48.00 | | do | |
| 2897 | T. F. Stuckle | do | J-3 | 1896 | Bored, 4-inch | 150 | | 78 | 33 | do | 49.50 | | do | |
| 2898 | E. Poyorane | do | J-3 | 1895 | Bored, 2-inch | 150 | | 30 | 52 | do | | | Domestic | |
| 2899 | J. M. McInnis | do | J-3 | 1892? | Bored, 4-inch | 151 | 141 | 25 | 46 | do | | | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2900 | W. C. Moore | do | J 2 | 1894 | Bored, 3-inch | 152 | | 65 | 40 | Wind | 37.00 | | do | |
| 2901 | A. P. Ramirez | do | J 2 | 1897 | Dug, 3 by 3 foot | 155 | 148 | 9 | 45 | do | | | do | |
| 2902 | Mrs. M. Theland | do | J 2 | 1894? | Bored, 4-inch | 157 | 146 | 72 | 39 | do | | | | |
| 2903 | L. J. Lane | do | J 2 | 1902 | do | 159 | | 105 | 33 | do | | | Domestic | |
| 2904 | James Graham | do | J 2 | 1895 | Bored, 2-inch | 161 | | 60 | 33 | do | | | Domestic; stock | |
| 2905 | do | do | J 2 | 1896? | Bored, 7-inch | 162 | 151 | 31 | 37 | Hand | | | Stock | |
| 2906 | John T. Jones | do | J-2 | 1896? | Bored, 4-inch | 164 | 154 | 88 | 35 | do | | | Domestic; stock | |
| 2907 | Mrs. M. Pheland | do | J-2 | 1876 | Bored, 7-inch | 167 | 156 | 42 | 35 | Wind | | | do | |
| 2908 | J. O. Rogers | do | J-2 | 1899 | Bored, 2-inch | 167 | | 55 | 34 | do | | | Domestic | |
| 2909 | J. T. Isbell | do | K-2 | 1887 | Bored, 4-inch | 170 | | 74 | 31 | do | | | Domestic; stock | |
| 2910 | do | do | K-2 | 1903 | do | 176 | | 63 | 36 | do | 53.50 | | do | |
| 2911 | Chas. Sanderson | do | K-2 | 1895? | Bored, 7-inch | 174 | 163 | 49 | 40 | Hand | | | Domestic | |
| 2912 | H. W. Judson | do | K-2 | 1899 | Hydraulic, 2-inch | 174 | | 70 | | Gas? | 35.00 | | do | |
| 2913 | do | do | K-2 | 1897 | Bored, 4-inch | 174 | | 68 | 30 | Wind | 70.00 | 40.00 | Domestic; stock | |
| 2914 | Pico School | do | K-1,2 | 1888? | do | 177 | | 68 | 28 | Hand | | | Domestic | |
| 2915 | M. Holbrook | do | K-1 | 1897 | do | 179 | | 65 | 27 | Wind | 55.00 | | Domestic; stock | |
| 2916 | Whittier Water Co | do | J, K-1 | 1898 | Bored, 12-inch | 195 | 178 | 152 | 27 | Compressed air | 380.00 | | Domestic | 56 |
| 2917 | do | do | J, K-1 | 1898 | do | 195 | 178 | 150 | | do | 375.00 | | do | |
| 2918 | Dan Phelan | do | K-1 | 1897 | Bored, 4-inch | 197 | 182 | 44 | 35 | Hand | 33.00 | | Domestic; stock | |
| 2919 | Theodore Castillo | do | K-1 | 1899 | Dug, 3 by 3 foot | 200 | 179 | 23 | 30 | do | | | Domestic | |
| 2920 | H. W. R. Strong | do | K-1 | 1870? | Bored, 7-inch | 212 | 158 | 75 | 80 | Wind | | | do | |
| 2921 | do | do | K-1 | 1902 | Bored, 10-inch | 210 | 166 | 500+ | | | | | Not used | |
| 2922 | R. McNees | do | K-2 | 1889? | Bored, 4-inch | 208 | 164 | 90 | 61 | Wind | | | Domestic | |
| 2923 | Whittier State School | do | L-2 | 1903 | Bored, 12-inch | 222 | 168 | 800 | | do | | | Domestic; stock | |
| 2924 | J. Sorensen | do | K-2 | 1878 | Bored, 7-inch | 203 | | 400 | | | 1,200.00 | | Not used | |
| 2925 | do | do | K-2 | 1878 | Dug, 3 by 3 foot | 202 | 164 | 46 | 92 | Wind | | | Domestic | |
| 2926 | A. King | do | K-2 | 1887 | Bored, 4-inch | 171 | | 65 | 72 | do | | | Domestic; stock | |
| 2927 | J. King | do | K-3 | 1888 | do | 167 | 157 | 52 | 68 | Hand | | | Stock | |
| 2928 | C. E. Archer | do | K-3 | 1900 | Bored, 7-inch | 165 | 156 | 80 | | Gas | 80.00 | | Irrigation | †45 |
| 2929 | do | do | K-3 | 1900 | Bored, 4-inch | 163 | | 60 | 63 | Wind | 35.00 | | Domestic | |
| 2930 | J. W. See | do | K-3 | 1898 | do | 165 | 156 | 51 | 63 | Hand | 48.00 | | do | |
| 2931 | do | do | K-3 | 1897? | do | 160 | 155 | 25 | 90 | do | 48.00 | | Stock | |
| 2932 | S. V. Gregg | do | K-3 | 1889? | do | 162 | 153 | 54 | 72 | do | | | Domestic | |
| 2933 | G. W. Cole | do | K-3 | 1892? | Bored, 7-inch | 164 | 153 | 75 | 98 | Wind | | | do | |
| 2934 | B. S. Cole | Santa Gertrudis | K-3 | 1897 | do | 161 | 152 | 72 | 91 | do | | | Domestic; stock | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2935 | E. R. King | Paso de Bartolo | K-3 | 1890? | Bored, 4-inch | 165 | | 54 | 57 | Wind | $50.00 | | Domestic | |
| 2936 | L. Terkelson | do | K-3 | 1901 | do | 162 | 153 | 49 | 47 | Hand | | | do | |
| 2937 | Mrs. M. A. Nicholson | do | K-3 | 1902 | Bored, 5-inch | 162 | 156 | 75 | 57 | do | 66.00 | | do | |
| 2938 | M. M. Burke | do | K-3 | 1903 | do | 166 | | 75 | 83 | Wind | | | do | |
| 2939 | C. C. Smith | do | K-3 | 1889? | Bored, 4-inch | 165 | | 75 | 47 | do | | | do | |
| 2940 | E. Johnson | do | K-3 | 1900 | do | 164 | 156 | 59 | 42 | Hand | 50.00 | | do | |
| 2941 | Mrs. M. J. King | do | K-3 | 1893? | do | 161 | | 65 | 36 | Wind | | | do | |
| 2942 | A. J. Nicholson | do | J, K-3 | 1903 | do | 158 | 149 | 59 | 42 | Hand | 50.00 | | Domestic; stock | |
| 2943 | Mrs. M. Burghardt | do | J-3 | 1895 | Bored, 2-inch | 155 | | 65 | 37 | do | | | Domestic | |
| 2944 | D. E. Poyorena | do | K-3 | | Bored, 4-inch | 155 | 146 | 49 | 41 | do | | | do | |
| 2945 | P. T. Swaine | do | J, K-3 | 1893 | Bored, 7-inch | 155 | 143 | 64 | 40 | Wind | | | do | |
| 2946 | A. B. Briswalter | do | K-3 | 1902 | Bored, 4-inch | 154 | 143 | 133 | 48 | Hand | 113.00 | | do | |
| 2947 | J. T. King | Santa Gertrudis | K-3 | 1902 | Bored, 6-inch | 156 | | 70 | 59 | Wind | | | Domestic; stock | |
| 2948 | Joe Hynes | do | K-3 | 1888 | Bored, 4-inch | 159 | 148 | 103 | 35 | do | | | Domestic | |
| 2949 | Geo. Hatch | Paso de Bartolo | K-3 | 1890? | do | 159 | | 70 | 37 | do | | | Domestic; stock | |
| 2950 | John Lewis | Santa Gertrudis | J-3 | 1898 | do | 156 | | 75 | 40 | do | | | Domestic | |
| 2951 | Los Nietos School | do | J, K-3 | | Bored, 6-inch | 156 | | 60 | 44 | Hand | | | do | |
| 2952 | Los Nietos Packing House. | do | J-4 | 1897 | Bored, 4-inch | 160 | 147 | 48 | 43 | do | | | Packing | |
| 2953 | L. Duran | do | J-4 | 1880? | Dug, 4 by 4 foot | 160 | 138 | 25 | 48 | do | | | Domestic | |
| 2954 | Mr. Girado | do | J-4 | | Dug, 2 by 3 foot | 162 | 137 | 27 | 41 | do | | | do | |
| 2955 | Max Schwede | do | J-4 | 1901 | Bored, 6-inch | 160 | | 92 | 39 | do | | | do | |
| 2956 | Lucy Girado | do | J-4 | 1901 | Bored, 7-inch | 159 | | 90 | 38 | do | | | do | |
| 2957 | Central Oil Wells | do | K-4 | 1900 | Bored, 4-inch | 157 | | 86 | 33 | do | | | do | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2958 | Murphy Oil Co. | do | K-4 | 1888 | do | 160 | | 117 | 32 | do | | | do | | | |
| 2959 | J. D. Ramirez | do | K-4 | 1901 | Bored, 7-inch | 161 | | 85 | 29 | Wind | | | do | | | |
| 2960 | D. C. Cartwright | do | K-4 | 1901 | Bored, 6-inch | 159 | | 70 | 35 | do | | | do | | | |
| 2961 | E. W. Pitman | do | K-4 | 1870 | Bored, 7-inch | 157 | 134 | 103 | 30 | do | | | do | | | |
| 2962 | F. A. Sanchez | do | K-4 | 1900 | do | 159 | 130 | 36 | 55 | do | | | do | | | |
| 2963 | do | do | K-4 | 1901 | Bored, 10-inch | 158 | 131 | 205 | | Compressed air | 270.00 | $1,700.00 | Irrigation | | 40 | |
| 2964 | T. L. Sanchez | do | K-4 | 1898 | Bored, 7-inch | 158 | | 90 | 58 | Wind | 81.00 | | Stock | | | |
| 2965 | Sophia Elisalea | do | K-4 | 1892 | Dug, 5-foot diameter. | 160 | 130 | 31 | 65 | Hand | | | Domestic | | | |
| 2966 | Mrs. Linares | do | K-4 | 1877 | Dug, 5 by 5 foot | 157 | 130 | 28 | 54 | do | | | do | | | |
| 2967 | do | do | K-4 | 1887 | Dug, 4 by 4 foot | 155 | 135 | 22 | 79 | do | | | do | | | |
| 2968 | V. D. Acost | do | K-4 | 1888 | do | 152 | 135 | 19 | 63 | do | | | do | | | |
| 2969 | G. Martinez | do | K-4 | 1898 | Dug, 2½ by 2½ foot. | 145 | 137 | 11 | 59 | do | | | do | | | |
| 2970 | Fred Valla | do | K-4 | 1903 | Bored, 4-inch | 148 | | 70 | 31 | do | 50.00 | | do | | | |
| 2971 | do | do | L-3 | 1896 | do | 145 | | 54 | 73 | Wind | 46.00 | | do | | | |
| 2972 | Geo. Quigley | do | L-3 | 1900 | Dug, 2 by 4 foot | 144 | 131 | 9 | | do | | | Domestic; stock | | | |
| 2973 | C. E. Cole | do | L-3 | 1899 | Bored, 7-inch | 146 | 135 | 107 | 56 | do | | | do | | | |
| 2974 | B. Sharpless | do | L-3 | 1887? | Bored, 4-inch | 149 | | 120 | 47 | do | | | Domestic | | | |
| 2975 | J. Cole | do | L-3 | | Bored, 7-inch | 162 | | 65 | 89 | do | | | do | | | |
| 2976 | Evergreen Water Co. | do | L-3 | 1900 | Bored, 9½-inch | 187 | 155 | 150 | | Gas | *5,400.00 | | Irrigation | | 125 | |
| 2977 | do | do | L-3 | 1900 | Bored, 12-inch | 187 | 155 | 84 | | do | | | do | | | |
| 2978 | J. Cole | do | L-3 | 1894 | Bored, 4-inch | 177 | 151 | 60 | 75 | Wind | | | Domestic | | | |
| 2979 | C. A. Landreth | do | L-3 | 1901 | do | 191 | 160 | 78 | 102 | Hand | 75.00 | | Domestic; stock | | | |
| 2980 | Santa Gertrudis Irrigation Co. | do | L-4 | 1899 | Bored, 10-inch | | | 53 | | | | | Not used | | | |
| 2981 | do | do | L-4 | 1898 | Bored, 7-inch | 143 | 136 | 54 | 88 | Steam | | | Irrigation | | †60 | |
| 2982 | do | do | L-4 | | Bored, 12-inch | 143 | 136 | 32 | | do | | | do | | | |
| 2983 | do | do | L-4 | 1899 | Bored, 10-inch | 143 | 136 | 52 | | do | | | do | | | |
| 2984 | do | do | L-4 | 1899 | do | 143 | | 44 | | | | | Not used | | | |
| 2985 | H. V. Vorce | do | L-4 | 1894 | Hydraulic, 2-inch. | 144 | | 50 | 81 | Hand | | | Domestic | | | |
| 2986 | do | do | L-4 | 1897 | Bored, 10-inch | 146 | 139 | 32 | | Gas | 75.00 | 450.00 | Irrigation | | 20 | |
| 2987 | P. M. Mowry | do | L-4 | 1901 | Driven, 1¼-inch | 145 | | 18 | 75 | Hand | | | Domestic | | | |
| 2988 | Gunn Ranch | do | L-4 | 1895? | Bored, 3-inch | 145 | | 40 | 63 | do | | | Domestic; stock | | | |
| 2989 | C. L. Wheeler | do | L-4 | 1900 | Bored, 7-inch | 150 | 125 | 45 | 107 | Gas | | | Irrigation | | †10 | |
| 2990 | Jacob Chase | do | L-4 | 1887? | Bored, 4-inch | 144 | 128 | 45 | 104 | Wind | | | Domestic | | | |
| 2991 | W. O. Graham | do | L, M-4 | 1895 | Driven, 1¼-inch | 146 | | 28 | 120 | Hand | | | do | | | |

*Wells in the Downey quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | | | | | *Miner's inches.* |
| 2992 | John Wood | Santa Gertrudis | M-4 | 1898 | Bored, 10-inch | 148 | 122 | 660 | 80 | Hand | | | Stock | |
| 2993 | do | do | M-4 | 1904 | Bored, 7-inch | 150 | 127 | 46 | | Wind | $50.00 | | Domestic | |
| 2994 | Colima Tract Water Co. | do | L-4,5 | 1892 | Bored, 10-inch | 133 | 118 | 152 | 83 | Compressed air. | 350.00 | | Irrigation | 110 |
| 2995 | do | do | L-4,5 | 1899 | do | 135 | 118 | 154 | | do | 350.00 | | do | |
| 2996 | V. Rais | do | L-5 | 1887? | Bored, 4-inch | 145 | | 35 | 63 | Wind | | | Domestic | |
| 2997 | T. Resndes | do | M-4,5 | 1898 | Dug, 3 by 3 foot | 146 | 130 | 19 | 120 | Hand | | | Domestic; stock | |
| 2998 | J. Sanchez | do | M-4 | 1901 | Bored, 4-inch | 183 | 148 | 47 | 75 | do | | | do | |
| 2999 | A. A. Gueirre | do | N-5 | 1900 | Dug, 4 by 4 foot | 209 | 178 | 33 | 89 | do | | | do | |
| 3000 | M. Contreras | do | N-5 | 1901 | Dug, 3-foot diameter. | 203 | 181 | 23 | 93 | do | | | Domestic | |
| 3001 | R. S Lambert | do | N-5 | 1895 | Dug, 3½-foot diameter. | 227 | 192 | 37 | 61 | do | | | do | |
| 3002 | G. W. Fulwider | do | N-4 | 1902 | Bored, 7-inch | 232 | 192 | 116 | 55 | Wind | 120.00 | $55.00 | Domestic; stock | |
| 3003 | Sam Mendenhall | do | N-5 | 1901 | Bored, 10-inch | 195 | 174 | 28 | 62 | do | | | do | |
| 3004 | H. L. Riggins | do | N-4 | 1900 | Bored, 6-inch | 255 | 185 | 190 | 57 | do | 200.00 | | do | |
| 3005 | Cyrus Baldwin | do | N-4 | 1901 | Bored, 7-inch | 278 | 190 | 165 | 48 | do | | | do | |
| 3006 | Chas. Scott | do | N-5 | 1897 | Bored, 4-inch | 225 | | 140 | | do | | | Not used | |
| 3007 | E. W. Cole | do | N-5 | 1895? | Bored, 7-inch | 222 | 182 | 90 | 55 | do | | | Domestic; stock | |
| 3008 | Walter Jackson | do | N-4 | 1901 | do | 253 | | 106 | 38 | Hand | | | do | |
| 3009 | Wm. K. Green | do | M,N-4 | 1896 | do | 270 | 180 | 327 | | | 500.00 | | Irrigation | |
| 3010 | N. Thill | do | M-4 | 1901 | Bored, 5-inch | 175 | | 62 | 120 | Wind | | | Domestic | |
| 3011 | Mrs. Stoddard | do | M-4 | 1897 | Bored, 4-inch | 168 | | 100 | 172 | do | | | do | |
| 3012 | J. B. Willey | do | M-4 | 1896 | do | 157 | | 58 | 130 | do | | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3013 | Woodward & Graham | do | M-4 | 1901 | Bored, 10-inch | 174 | 110 | 85 | 106 | Gas | 300.00 | | Irrigation | †60 |
| 3014 | T. H. Woodward | do | M-4 | 1900 | Bored, 7-inch | 173 | 130 | 65 | 106 | Wind | | | Domestic | |
| 3015 | J. L. Gales | do | M-4 | 1892 | Bored, 4-inch | 188 | | 130 | | Hand | | | Not used | |
| 3016 | E. W. Hazzard | do | M-4 | 1890 | do | 163 | | 98 | 126 | Wind | | | Domestic | |
| 3017 | W. T. Brookaw | do | L-4 | 1897 | Bored, 7-inch | 167 | | 78 | 134 | Hand | | | do | |
| 3018 | Geo. L. Hazzard | do | L, M-3 | 1895 | do | 215 | | 165 | | Wind | | | Not used | |
| 3019 | H. C. Baldwin | do | M-3 | 1892? | do | 280 | 155 | 154 | | do | | | | |
| 3020 | J. B. Willey | do | L, M-5 | 1888? | do | 127 | 127 | 170 | 91 | Artesian | | | | 2 |
| 3021 | C. M. Mayer | do | N-4 | 1903 | do | 265 | 173 | 163 | 32 | Gas | | 150.00 | Irrigation | †1 |

## *Wells in Las Bolsas quadrangle.*

[* Cost of well and equipment combined; † yield estimated or statement of owner taken; ? doubtful.]

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Temperature of water. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | °*F.* | | | | | *Miner's inches.* |
| 1 | M. J. Edwards | La Bolsa Chica | M-1 | 1874 | Bored, 7-inch | 19 | 19 | 116 | 25 | 64 | Artesian | | | Irrigation | 29 |
| 2 | Chico district school | do | M-1 | 1894 | Bored, 2-inch | 21 | 21 | 300 | 27 | 64 | do | | | Domestic | 4 |
| 3 | W. J. Edwards | do | M-1 | 1896 | do | 20 | 20 | 125 | 26 | 64 | do | $50.00 | | Irrigation; domestic. | 4 |
| 4 | do | do | M-2 | 1899 | Bored, 3-inch | 20 | 20 | 128 | 25 | 65 | do | 60.00 | | Irrigation | 8 |
| 5 | do | do | M-2 | 1898 | Bored, 3½-inch | 19 | 19 | 130 | 26 | 64 | do | | | do | 10 |
| 6 | do | do | M-2 | 1899 | Bored, 2-inch | 19 | 19 | 114 | 26 | 64 | do | 45.00 | | do | †5 |
| 7 | do | do | M-2 | 1899 | do | 18 | 18 | 165 | 26 | 64 | do | 65.00 | | do | 4 |
| 8 | do | do | N-2 | 1901 | Bored, 4-inch | 19 | 19 | 64 | 26 | 64 | do | 35.00 | | do | 4 |
| 9 | do | do | M-2 | 1900 | do | 19 | 19 | 170 | | | do | | | do | †3 |
| 10 | do | do | M-2 | 1896 | Bored, 2-inch | 19 | 19 | 72 | | | do | 30.00 | | do | †4 |

*Wells in Las Bolsas quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Temperature of water. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | °*F.* | | | | | *Miner's inches.* |
| 11 | W. J. Edwards | La Bolsa Chica | N-2 | 1898 | Bored, 3¼-inch | 19 | 19 | 74 | 26 | 65 | Artesian | $30.00 | | Irrigation | 3 |
| 12 | do | do | N-2 | 1898 | do | 19 | 19 | 75 | | | do | | | do | †4 |
| 13 | do | do | M-2 | 1898 | do | 19 | 19 | 75 | 30 | 64 | do | | | Not used | |
| 14 | do | do | M-1 | 1898 | do | 20 | 20 | 194 | 27 | 65 | do | | | Irrigation; stock. | 10 |
| 15 | do | do | M-2 | 1897 | Bored, 7-inch | 20 | 20 | 160 | 26 | 65 | do | | | Irrigation | 1 |
| 16 | do | do | N-1 | 1898 | Bored, 2-inch | 20 | 20 | 119 | | | do | 45.00 | | do | †2 |
| 17 | do | do | M-2 | 1899 | Bored, 3-inch | 18 | 18 | 120 | 26 | 65 | do | 65.00 | | do | †3 |
| 18 | Samson Edwards | do | M-1 | 1900 | Bored, 2-inch | 19 | 19 | 135 | 26 | 64 | do | 50.00 | | do | †4 |
| 19 | do | do | M-2 | 1900 | Bored, 3-inch | 19 | 19 | 135 | 26 | 64 | do | | | do | 10 |
| 20 | do | do | M-1 | 1898 | Bored, 3½-inch | 19 | 19 | 135 | 27 | 64 | do | | | do | 8 |
| 21 | do | do | M-2 | 1902 | Bored, 6-inch | 16 | 16 | 230 | | | do | | | do | †26 |
| 22 | Frank Bohannan | do | M-2 | 1901 | Bored, 2-inch | 16 | 16 | 100 | 25 | 64 | do | 40.00 | | do | 4 |
| 23 | do | do | M-2 | 1902 | Bored, 4-inch | 15 | 15 | 214 | | | do | 100.00 | | do | 4 |
| 24 | W. J. Edwards | do | M-2 | 1901 | do | 15 | 15 | 100 | 27 | 64 | do | 35.00 | | do | 4 |
| 25 | do | do | M-2 | | Bored, 3½-inch | 15 | 15 | | | | do | | | do | 4 |
| 27 | W. H. Johnson | do | M-2 | | Bored, 2-inch | 21 | 21 | 127 | 25 | 64 | do | | | do | 2 |
| 28 | do | do | M-2 | | do | 15 | 15 | 130 | | 65 | do | | | do | 2 |
| 28a | do | do | M-2 | | Bored, 7-inch | 15 | 15 | 238 | 25 | 68 | do | | | do | 9 |
| 29 | do | do | M-2 | | Bored, 2-inch | 15 | 15 | 77 | | | do | | | do | 6 |
| 30 | do | do | M-2 | | Bored, 4-inch | 15 | 15 | 160 | 26 | 65 | do | | | do | |
| 31 | Sampson Edwards | do | M-2 | 1904 | do | 15 | 15 | 68 | 27 | 64 | do | | | do | 17 |
| 32 | do | do | M-2 | 1900 | do | 15 | 15 | 70 | | | do | | | do | 14 |
| 33 | do | do | M-3 | 1898 | Bored, 2-inch | 14 | 14 | 60 | | | do | | | do | 4 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | do | do | M 3 | 1900 | Bored, 4-inch | 14 | 14 | 68 | | | do | | do | 13 |
| 35 | John Edwards | do | M 2 | | do | 15 | 15 | | 25 | 65 | do | | do | |
| 36 | do | do | M-2 | | Bored, 8-inch | 15 | 15 | 53 | 25 | 65 | do | | do | 3 |
| 37 | do | do | M-2 | 1898 | Bored, 3½-inch | 15 | 15 | 115 | | | do | | Not used | |
| 38 | Wm. Kasemann | do | M-2 | 1903 | Bored, 3-inch | 15 | 15 | 146 | | | do | | do | †10 |
| 39 | Samuel King | do | M-2 | 1904 | Bored, 4-inch | 16 | 16 | 73 | | | do | | Irrigation | 20 |
| 40 | do | do | M-2 | 1899 | do | 16 | 16 | 200 | | | do | | do | 8 |
| 41 | do | do | M-2 | 1897 | do | 16 | 16 | 165? | 27 | 64 | do | | Domestic; irrigation. | 21 |
| 42 | do | do | M-2 | 1897 | do | 16 | 16 | 165 | | | do | | Irrigation | 18 |
| 43 | W. W. Barton | do | M-2 | 1903 | do | 16 | 16 | 160 | 26 | 64 | do | | do | 15 |
| 44 | do | do | M, N-2 | 1896 | Driven, 4-inch | 17 | 17 | 200 | 27 | 64 | do | | | |
| 45 | do | do | N-2 | 1903 | Bored, 4-inch | 17 | 17 | 82 | | | do | | Irrigation | †28 |
| 46 | do | do | N-2 | 1897 | Bored, 2-inch | 17 | 17 | 184 | 27 | 65 | do | | do | 5 |
| 47 | do | do | N-2 | 1903 | Bored, 4-inch | 17 | 17 | 192 | | | do | | do | †15 |
| 48 | do | do | M-2 | 1901 | do | 17 | 17 | 184 | 26 | 65 | do | | do | †14 |
| 49 | do | do | N-2 | 1899 | do | 17 | 17 | 220 | | 65 | do | | | †14 |
| 50 | G. W. More | do | N-2 | 1898 | do | 17 | 17 | 78 | 26 | 64 | do | | | 5 |
| 51 | do | do | N-2 | 1899 | do | 18 | 18 | 80 | | | do | | | 5 |
| 52 | do | do | N-2 | 1898 | do | 17 | 17 | 80 | 27 | 64 | do | | | 14 |
| 53 | do | do | N-2 | 1900 | Bored, 7-inch | 16 | 16 | 82 | | | do | | Irrigation | 7 |
| 54 | do | do | N-2 | 1900 | do | 16 | 16 | 86 | | | do | | | 19 |
| 55 | Geo. Johnson | do | N-2 | | Bored, 3-inch | 15 | 15 | 90 | 26 | | do | | Irrigation | 12 |
| 56 | B. R. Gerhart | do | N-2 | 1896 | Bored, 4-inch | 15 | 15 | 69 | 25 | 66 | do | | Domestic; irrigation. | 14 |
| 57 | do | do | N-3 | 1904 | do | 14 | 14 | 77 | 28 | 65 | do | | Irrigation | †22 |
| 58 | do | do | N-3 | 1900 | do | 15 | 15 | 72 | | | do | | do | 14 |
| 59 | W. E. Gerhart | do | N-2,3 | | do | 15 | 15 | 98 | 25 | 64 | do | | do | |
| 60 | do | do | N-2,3 | 1899 | do | 16 | 16 | 80 | | | do | | Stock; irrigation. | 8 |
| 61 | do | do | N-3 | 1896 | do | 17 | 17 | 80 | 26 | 64 | do | | Irrigation | 5 |
| 62 | Dave Rogers | do | N-2 | 1896 | Bored, 7-inch | 16 | 16 | 155 | | | do | 120.00 | Domestic; irrigation. | 9 |
| 63 | R. R. Gerhart | do | N-2 | 1904 | Bored, 4-inch | 17 | 17 | 80 | 26 | 64 | do | | Irrigation | †18 |
| 64 | J. T. Shaffer | do | N-2 | 1904 | do | 17 | 17 | 72 | | | do | | do | †17 |
| 65 | do | do | N-2 | 1898 | do | 17 | 17 | 65 | 26 | 63 | do | | do | †20 |
| 66 | do | do | N-2 | 1897 | do | 17 | 17 | 70 | | | do | | do | †17 |

*Wells in Las Bolsas quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Temperature of water. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | *°F.* | | | | | | *Miner's inches.* |
| 67 | J. T. Shaffer | La Bolsa Chica | N-2 | 1899 | Bored, 7-inch | 17 | 17 | 128 | | | Artesian | | | Irrigation | †81 |
| 68 | T. J. Lewis | do | N-2 | 1899 | do | 16 | 16 | 90? | | | do | $100.00 | | do | 12 |
| 69 | do | do | N-3 | 1901 | do | 15 | 15 | 65 | | | do | 90.00 | | do | †19 |
| 70 | R. R. & I. J. Gerhart | do | N-3 | 1896 | Bored, 4-inch | 15 | 15 | 80 | 28 | 64 | do | | | do | 8 |
| 71 | do | do | N-3 | 1900 | Hydraulic, 3-inch | 15 | 15 | 80? | | | do | | | do | 3 |
| 72 | Geo. Gerhart | do | N-3 | 1899 | Bored, 4-inch | 14 | 14 | 74 | 26 | 64 | do | | | do | 14 |
| 73 | do | do | M, N-3 | 1900 | do | 13 | 13 | 76 | | | do | | | do | †17 |
| 74 | H. H. Bentley | do | N-3 | 1897 | Bored, 2-inch | 16 | 16 | 71 | 25 | 64 | do | 30.00 | | Stock; irrigation. | †7 |
| 75 | do | do | N-3 | 1901 | Bored, 4-inch | 16 | 16 | 72 | | | do | 40.00 | | Irrigation | †20 |
| 76 | do | do | M-2,3 | 1902 | Bored, 2-inch | 16 | 16 | 71 | | | do | 30.00 | | do | 5 |
| 77 | B. A. Farrer | do | N-3 | 1898 | Bored, 4-inch | 16 | 16 | 72 | 26 | 64 | do | | | Domestic; irrigation. | 8 |
| 78 | do | do | N-3 | 1901 | do | 14 | 14 | 78 | | | do | 40.00 | | Irrigation | †19 |
| 79 | do | do | N-3 | 1904 | do | 15 | 15 | 78 | | | do | 40.00 | | do | †18 |
| 80 | W. T. Clark | do | M-3 | 1903 | do | 13 | 13 | 76 | 26 | 64 | do | | | do | 17 |
| 81 | do | do | M-3 | 1898 | do | 13 | 13 | 74 | | 64 | do | 40.00 | | do | 10 |
| 82 | do | do | M-3 | 1898 | Bored, 7-inch | 13 | 13 | 73 | | | do | 100.00 | | do | 7 |
| 83 | W. H. McGirk | do | N-3 | 1901 | Bored, 2-inch | 13 | 13 | 70 | 25 | 66 | do | | | Domestic; irrigation. | †8 |
| 84 | do | do | N-3 | 1900 | do | 12 | 12 | 68 | | | do | 30.00 | | Irrigation | †8 |
| 85 | D. McGirk | do | N-3 | 1904 | do | 13 | 13 | 74 | | | do | 35.00 | | do | †9 |
| 86 | do | do | N-3 | 1895 | Bored, 4-inch | 12 | 12 | 75 | 26 | 64 | do | | | Domestic; irrigation. | 17 |
| 87 | D. H. Thompson | do | N-3 | 1901 | Bored, 2-inch | 14 | 14 | 72 | | | do | 35.00 | | Irrigation | 8 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 88 | M. C. Cole | do | N-3 | 1895 | Bored, 4-inch | 15 | 15 | 85 | 25 | 64 | do | 45.00 | | Domestic; irrigation. | | 12 |
| 89 | F. J. Mallott | do | N-3 | 1897 | Bored, 7-inch | 17 | 17 | 120 | 27 | 65 | do | 90.00 | | do | | 7 |
| 90 | do | do | N-3 | 1901 | do | 16 | 16 | 140 | | | do | 125.00 | | Irrigation | | †29 |
| 91 | Joseph Walton | do | N-3 | 1899 | do | 16 | 16 | 100 | | | do | | | do | | 9 |
| 92 | J. G. Blaylock | do | N-3 | 1896 | do | 16 | 16 | 90 | 26 | 63 | do | 75.00 | | Domestic | | |
| 93 | J. M. Cain | do | N-3 | 1900 | Hydraulic, 3-inch | 16 | 16 | 59 | | | do | 30.00 | | Irrigation | | 10 |
| 94 | do | do | N-3 | | Hydraulic, 2-inch | 16 | 16 | 155 | | | Wind | 75.00 | $40.00 | Domestic; irrigation. | | |
| 95 | J. L. Worthy | do | N-3 | 1900 | Hydraulic, 3-inch | 16 | 16 | 130 | | | Artesian | 75.00 | | do | | |
| 97 | Henry Winters | do | N-3 | 1895 | Hydraulic, 2-inch | 16 | 16 | 138 | 28 | 65 | do | | | do | | |
| 98 | do | do | N-3 | 1896 | Bored, 4-inch | 16 | 16 | 138 | | | do | | | Irrigation | | †20 |
| 99 | Jacob Walton | do | N-3 | 1896 | Bored, 7-inch | 17 | 17 | 136 | | | do | | | do | | †29 |
| 100 | W. S. Burdick | do | N-2 | 1896 | do | 18 | 18 | 85? | 27 | 63 | do | 75.00 | | Domestic; irrigation. | | 7 |
| 101 | do | do | N-2 | 1899 | Bored, 3-inch | 18 | 18 | 90? | 27 | 64 | do | 45.00 | | Irrigation | | †8 |
| 102 | D. Rogers | do | N-2 | 1898 | Bored, 2-inch | 18 | 18 | 85 | | | do | 35.00 | | Domestic; irrigation. | | 4 |
| 103 | do | do | N-2 | 1900 | Bored, 7-inch | 18 | 18 | 84 | | | do | | | Irrigation | | 2 |
| 104 | do | do | N-2 | 1899 | Bored, 2-inch | 17 | 17 | 85 | | | do | 40.00 | | do | | 4 |
| 105 | A. J. Crane | do | N-2 | 1895 | Bored, 7-inch | 17 | 17 | 79 | 25 | 64 | do | | | Domestic; irrigation. | | 7 |
| 106 | do | do | N-2 | 1900 | do | 17 | 17 | 175 | 25 | 64 | do | 250.00 | | Irrigation | | 7 |
| 107 | Golden West Celery and Produce Co. | do | N-2 | 1903 | Bored, 4-inch | 17 | 17 | 198 | 23 | 64 | do | | | Domestic; irrigation. | | 16 |
| 108 | do | do | N-2 | 1894 | Bored 7-inch | 18 | 18 | 100 | 27 | 64 | do | | | Irrigation | | 24 |
| 109 | do | do | N-2 | 1893 | do | 18 | 18 | 90 | | | do | 100.00 | | do | | 1 |
| 111 | do | do | N-2 | 1901 | Bored, 3-inch | 17 | 17 | 98 | 27 | 64 | do | 65.00 | | do | | 8 |
| 112 | do | do | N-2 | 1901 | Bored, 7-inch | 17 | 17 | 96 | | | do | | | do | | 7 |
| 113 | do | do | N-2 | 1901 | Bored, 2-inch | 17 | 17 | 120 | | | do | 60.00 | | do | | 4 |
| 114 | do | do | N-2 | 1896 | Bored, 7-inch | 17 | 17 | 188 | 26 | 65 | do | | | do | | 2 |
| 115 | do | do | N-2 | 1892 | do | 17 | 17 | 97 | | | do | | | do | | †7 |
| 116 | do | do | N-2 | 1901 | Bored, 3-inch | 17 | 17 | 120 | | | do | | | do | | 10 |
| 117 | do | do | N-3 | 1901 | do | 17 | 17 | 110 | | | do | | | do | | 9 |
| 118 | do | do | N-2 | 1894 | Bored, 4-inch | 17 | 17 | 110 | 26 | 64 | do | | | do | | 8 |
| 119 | do | do | N-3 | 1894 | Hydraulic, 4-inch | 17 | 17 | 108 | | | do | | | do | | 8 |
| 120 | do | do | N-3 | 1896 | Bored, 4-inch | 17 | 17 | 140 | | | do | | | do | | 15 |

*Wells in Las Bolsas quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Temperature of water. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | °*F.* | | | | | *Miner's inches.* |
| 123 | B. B. Townsend | La Bolsa Chica | N-2 | 1903 | Bored, 4-inch | 17 | 17 | 260 | 25 | 66 | Artesian | $200.00 | | Irrigation | †20 |
| 124 | do | do | N-2 | | Bored, 7-inch | 17 | 17 | 160 | | | do | | | do | †24 |
| 125 | J. O. Slaback | do | N-2 | 1901 | Bored 4-inch | 17 | 17 | 68 | 27 | 64 | do | 40.00 | | do | †21 |
| 126 | Wm. Kasemann | do | N-2 | 1900 | Bored, 7-inch | 18 | 18 | 367 | 24 | 64 | do | 400.00 | | Domestic; irrigation; stock. | 8 |
| 127 | do | do | N-2 | 1901 | Bored 3-inch | 19 | 19 | 196 | | | do | 120.00 | | Irrigation | 10 |
| 128 | do | do | N-2 | 1903 | Bored, 3½-inch | 18 | 18 | 194 | 28 | 64 | do | | | do | 8 |
| 129 | T. J. Lewis | do | N-2 | | Bored, 7-inch | 18 | 18 | 86 | 29 | 64 | do | | | Domestic; irrigation. | †7 |
| 130 | do | do | N-2 | 1904 | Bored, 4½-inch | 18 | 18 | 193 | 29 | 64 | do | | | Irrigation | 5 |
| 131 | Mr. Hazeltine | do | N-2 | 1901 | Bored, 2-inch | 19 | 19 | 128 | 27 | 65 | do | 60.00 | | Domestic; stock | 4 |
| 132 | do | do | N-2 | | Bored, 3-inch, inside of 7-inch. | 19 | 19 | 324 | 27 | 64 | do | | | Irrigation | 2 |
| 133 | W. T. Clark | do | N-2 | 1900 | Bored, 2-inch | 20 | 20 | 209 | | | do | 60.00 | | Domestic; irrigation; stock. | 5 |
| 134 | do | do | N-2 | 1904 | Hydraulic, 4-inch. | 17 | 17 | 232 | 32 | 64 | do | | | Irrigation | 18 |
| 135 | do | do | N-1 | 1896 | Bored, 7-inch | 18 | 18 | 75 | | | do | 45.00 | | do | 10 |
| 136 | do | do | N-1 | 1897 | do | 18 | 18. | 75 | 30 | 64 | do | | | do | 2 |
| 137 | do | do | N-2 | 1880 | do | 19 | 19 | 80 | 29 | 64 | do | 55.00 | | Irrigation; domestic. | 4 |
| 138 | do | do | N-1 | 1896 | do | 22 | 22 | 82 | | | do | 55.00 | | Irrigation | 4 |
| 139 | W. H. Edwards | do | N-1 | | do | 22 | 22 | 120 | 33 | 64 | do | | | do | 24 |
| 140 | do | do | N-1 | | do | 20 | 20 | 104 | 29 | 64 | do | | | do | 12 |
| 141 | do | Las Bolsas | N-1 | | Bored, 2-inch | 20 | 20 | 97 | 30 | 64 | do | | | do | 6 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 142 | R. E. Larter | do | N-1 | 1874 | Bored, 7-inch | 25 | 25 | 102 | | 64 | do | | | Domestic; irrigation. | |
| 143 | do | do | N-1 | 1904 | Hydraulic, 3-inch | 25 | 25 | 357 | 28 | 64 | do | | | Irrigation | 12 |
| 144 | Mr. Wayman | do | N-1 | | Bored, 2-inch | 22 | 22 | 80 | 33 | 64 | do | | | Irrigation; stock | |
| 145 | R. E. Larter | do | N-1 | | Bored, 7-inch | 22 | 22 | 295 | 27 | 64 | do | | | Irrigation | 9 |
| 146 | H. F. Penhall | do | N-1 | 1904 | Hydraulic, 3-inch | 23 | 23 | 315 | 28 | 64 | do | 200.00 | | do | 11 |
| 147 | do | do | N-1 | 1884 | Bored, 7-inch | 23 | 23 | 80 | | | do | | | do | Small. |
| 148 | do | do | N-1 | 1902 | Hydraulic, 2-inch | 24 | 24 | 327 | | | do | | | do | 4 |
| 149 | Mrs. M. J. Larter | do | M, N-1 | | Bored, 7-inch | 22 | 22 | 72 | 30 | 64 | do | | | Irrigation; stock | †6 |
| 150 | E. M. Keller | La Bolsa Chica | M-1 | | do | 20 | 20 | 141 | 26 | 64 | do | | | Domestic; irrigation. | 4 |
| 151 | do | do | M-1 | | Bored, 2-inch | 19 | 19 | 100 | 26 | 64 | do | | | Irrigation | Small. |
| 152 | do | do | M-1 | | do | 19 | 19 | 123 | 25 | 64 | do | | | do | 4 |
| 153 | Mrs. H. Rogers | do | M-1 | 1900 | Bored, 3-inch | 17 | 17 | 232 | 26 | 66 | do | | | Domestic; stock | 10 |
| 154 | do | do | M-1 | 1876 | Bored, 7-inch | 17 | 17 | 87 | | | do | | | Domestic | Small. |
| 155 | J. Peters | do | L-1 | | do | 17 | 17 | 89 | 26 | 65 | do | | | Domestic; stock | Small. |
| 156 | Frank Wakeham | do | L-1 | | Bored, 3-inch | 20 | 20 | 210 | 23 | 66 | do | | | Irrigation | 6 |
| 157 | J. H. Edwards | Las Bolsas | N-1 | | do | 22 | 22 | 90 | 30 | 64 | do | | | Not used | 10 |
| 158 | do | do | N-1 | 1899 | Bored, 7-inch | 22 | 22 | 137 | | 64 | do | | | Irrigation | 9 |
| 159 | do | do | N-1 | 1899 | Bored, 3-inch | 21 | 21 | 117 | 29 | 64 | do | | | do | 10 |
| 160 | Mr. Keifhaber | do | N-1 | 1877 | Bored, 7-inch | 22 | 22 | 100 | 29 | 64 | do | | | Irrigation; stock | 12 |
| 163 | A. B. Bohnham | do | N-1 | 1876? | do | 27 | 27 | 48 | 36 | 64 | do | | | Domestic; stock | Small. |
| 164 | C. N. Hickox | La Bolsa Chica | L-2 | 1902 | Bored, 4-inch | 20 | 20 | 136 | 27 | 63 | do | | | Domestic; irrigation. | †14 |
| 165 | Chas. Waters | do | L-2 | 1903 | Bored, 2-inch | 20 | 20 | 90 | | 63 | do | | | Irrigation | |
| 166 | do | do | L-2 | 1903 | Hydraulic, 2-inch | 20 | 20 | 51 | | | do | | | Irrigation; stock | 2 |
| 167 | do | do | L-2 | 1901 | Bored, 4-inch | 17 | 17 | 110 | 25 | 65 | do | | | Irrigation | |
| 168 | A. D. Cleaver | do | L-2 | 1901 | do | 17 | 17 | 144 | 25 | 66 | do | | | do | 2 |
| 169 | J. J. Graham | do | M-3 | 1901 | Bored, 7-inch | 30 | 30 | 302 | 25 | 70 | do | | | Domestic; irrigation. | 2 |
| 170 | do | do | M-3 | 1901 | do | 30 | 30 | 274 | | | do | | | Irrigation; stock | 2 |
| 171 | W. Shamrack | do | M-3 | 1903 | Bored, 2-inch | 16 | 16 | 55 | 27 | | do | | | Irrigation | 6 |
| 172 | do | do | M-3 | 1903 | do | 16 | 16 | 58 | | | do | | | do | 6 |
| 173 | Ed. More | do | M-3 | 1899? | Bored, 4-inch | 17 | 17 | 70 | | | do | | | do | 4 |
| 174 | do | do | M-3 | 1904 | Bored, 3½-inch | 25 | 25 | 70 | 24 | 64 | do | | | do | 12 |
| 175 | do | do | M-3 | 1904 | do | 17 | 17 | 281 | 24 | 69 | do | | | do | 15 |

*Wells in Las Bolsas quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Temperature of water. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | °*F.* | | | | | *Miner's inches.* |
| 176 | A. D. Cleaver | La Bolsa Chica | M-3 | 1904 | Bored, 3-inch | 17 | 17 | 84 | 24 | 64 | Artesian | | | Irrigation | 10 |
| 177 | Wm. Metzger | do | M-3 | | Bored, 2-inch | 16 | 16 | 100 | 25 | 64 | do | | | do | |
| 178 | do | do | M-3 | | Bored, 7-inch | 17 | 17 | 64 | | | do | | | do | 4 |
| 179 | Mr. Robertson | do | M-3 | | do | 16 | 16 | | 26 | 64 | do | | | do | |
| 181 | W. H. Bently | do | M-3 | 1897 | Hydraulic, 2-inch | 17 | 17 | 135 | | | do | | | Stock | 5 |
| 182 | J. B. Robertson | do | M-3 | 1903 | Bored, 2-inch | 16 | 16 | 70 | 27 | 64 | do | | | Irrigation | |
| 183 | J. M. Waters | do | M-3 | 1902 | do | 16 | 16 | 65 | | | do | | | do | 7 |
| 184 | do | do | M-3 | 1902 | do | 14 | 14 | 66 | 26 | 66 | do | | | Domestic; stock | 5 |
| 185 | do | do | M-3 | 1900 | do | 14 | 14 | 66 | | | do | | | Irrigation | 4 |
| 186 | do | do | M-4 | 1898 | Bored, 4-inch | 14 | 14 | 67 | | | do | | | do | †2 |
| 187 | L. R. Metzger | do | M-3 | | do | 15 | 15 | 80 | 25 | 66 | do | | | do | †26 |
| 188 | do | do | M-3 | | Bored, 2-inch | 15 | 15 | 60 | | | do | | | | 4 |
| 191 | Wm. Shamrack | do | L-3 | 1898 | Bored, 3-inch | 20 | 20 | 70? | 21 | | Wind | | | Domestic; stock | |
| 192 | do | do | L, M-3 | 1904 | Bored, 7-inch | 14 | 14 | 220 | 24 | 70 | Artesian | | | Irrigation | 7 |
| 193 | John McDonald | do | M-3 | 1894? | Bored, 6-inch | 15 | 15 | 53 | 22 | 66 | do | | | do | 36 |
| 194 | Las Bolsas Land Co. | do | L-3 | | Hydraulic, 2-inch | 12 | 12 | 48 | 21 | 66 | do | | | Duck pond | 4 |
| 195 | do | do | L-3 | | do | 14 | 14 | 55 | 22 | 65 | do | | | do | 6 |
| 196 | do | do | L-3 | | do | 13 | 13 | 48 | | | do | | | do | 6 |
| 197 | Geo. Travoli | do | M-3 | 1899 | Hydraulic, 3-inch | 15 | 15 | 65 | 25 | 64 | do | | | Irrigation | †10 |
| 198 | do | do | M-3 | 1903 | do | 15 | 15 | 100? | | | do | | | do | †6 |
| 199 | do | do | M-3 | 1899 | Hydraulic, 2-inch | 15 | 15 | 70 | | | do | $35.00 | | do | 5 |
| 200 | do | do | M-3 | 1902 | do | 15 | 15 | 73 | | | do | 35.00 | | Domestic; stock | 4 |
| 201 | do | do | M-3 | 1900 | do | 15 | 15 | 68 | | | do | 30.00 | | Irrigation | 5 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 202 | do | do | M-4 | 1898 | Bored, 2-inch | 15 | 15 | 66 | | | do | | | do | †6 |
| 203 | do | do | M-4 | 1898 | Hydraulic, 3-inch | 15 | 15 | 70 | 27 | 64 | do | 40.00 | | do | 4 |
| 204 | do | do | M-4 | 1903 | do | 15 | 15 | 66 | | | do | 38.00 | | do | †12 |
| 205 | do | do | N-4 | 1904 | do | 14 | 14 | 75 | 33 | 65 | do | 39.00 | | do | 9 |
| 206 | do | do | N-3 | 1899 | Hydraulic, 2-inch | 14 | 14 | 67 | 27 | 64 | do | 30.00 | | do | 5 |
| 207 | J. B. Robertson | do | M-3 | 1900 | Hydraulic, 4-inch | 15 | 15 | 70? | | | do | | | do | 15 |
| 208 | do | do | M-3 | 1901 | Hydraulic, 2-inch | 14 | 14 | 70 | | | do | 32.00 | | do | |
| 209 | T. M. Robertson | do | M-3 | 1903 | Hydraulic, 4-inch | 15 | 15 | 85 | 25 | 64 | do | 54.00 | | do | 5 |
| 210 | do | do | M-3 | 1901 | Hydraulic, 2-inch | 14 | 14 | 70 | | | do | | | do | †5 |
| 211 | do | do | M-3 | 1902 | Hydraulic, 4-inch | 15 | 15 | 70 | 27 | 65 | do | 45.00 | | do | 15 |
| 212 | do | do | M-3 | 1902 | do | 15 | 15 | 70 | 27 | 65 | do | 45.00 | | do | 15 |
| 214 | W. L. Phillipps | do | N-4 | 1900 | Hydraulic, 2-inch | 14 | 14 | 68 | 27 | 65 | do | | | do | †6 |
| 215 | do | do | M-4 | 1904 | do | 14 | 14 | 67 | | | do | | | do | †7 |
| 216 | do | do | N-4 | 1901 | do | 14 | 14 | 60? | | | do | | | do | 6 |
| 217 | do | do | M-4 | 1900 | do | 14 | 14 | | 25 | 66 | do | | | do | †6 |
| 218 | D. F. Sharratt | do | N-3 | 1904 | Bored, 2-inch | 24 | 24 | 350 | 22 | 70 | do | | | do | 6 |
| 219 | do | do | N-3 | 1897 | Bored, 3-inch | 23 | 23 | 148 | 27 | 64 | do | | | do | 5 |
| 220 | Mrs. M. M. Shaffer | do | N-3 | 1902 | Hydraulic, 3-inch | 24 | 24 | 107 | 26 | 66 | do | 56.00 | | Domestic; irrigation. | 4 |
| 221 | do | do | N-3 | 1903 | Bored, 4-inch | 18 | 18 | 113 | | | do | | | Irrigation | 16 |
| 222 | do | do | N-3 | 1900 | do | 18 | 18 | 105 | | | do | | | do | †17 |
| 223 | C. J. & S. Buck | do | M-4 | 1895 | Bored, 3-inch | 14 | 14 | 75? | 26 | 65 | do | | | do | 9 |
| 224 | do | do | M-4 | 1903 | Bored, 4-inch | 14 | 14 | 70 | | | do | 45.00 | | do | †20 |
| 225 | P. B. O'Reilley | do | N-3 | 1902 | Bored, 2-inch | 16 | 16 | 70 | 26 | 65 | do | 30.00 | | Domestic; irrigation. | 6 |
| 226 | do | do | N-3 | 1902 | do | 17 | 17 | 70 | | | do | | | Irrigation | †6 |
| 227 | A. F. Lintner | do | N-3 | 1901 | do | 15 | 15 | 68 | 27 | 65 | do | 29.00 | | Irrigation; domestic. | 6 |
| 228 | do | do | N-3 | 1903 | Hydraulic, 2-inch | 17 | 17 | 84 | | | do | 40.00 | | Irrigation | 5 |
| 229 | do | do | N-4 | 1899 | Bored, 2-inch | 15 | 15 | 65 | 27 | 64 | do | 30.00 | | do | 4 |
| 230 | do | do | N-4 | 1898 | do | 15 | 15 | 68 | | | do | 30.00 | | do | 4 |
| 231 | do | do | N-4 | 1899 | do | 15 | 15 | 65 | 27 | 64 | do | 30.00 | | do | 4 |
| 232 | Dennis McGirk | do | N-4 | 1901 | do | 15 | 15 | 75 | | | do | | | Irrigation; stock | 4 |
| 233 | do | do | N-4 | 1902 | do | 14 | 14 | 76 | 26 | 65 | do | 33.00 | | Irrigation | 4 |
| 234 | D. H. Thomas | do | N-3 | 1899 | Bored, 4-inch | 16 | 16 | 74 | | | do | 50.00 | | do | †14 |
| 235 | M. C. Cole | do | N-3 | 1900 | Bored, 2-inch | 15 | 15 | | | | do | | | do | 6 |

*Wells in Las Bolsas quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000 | Temperature of water. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | °*F.* | | | | | *Miner's inches.* |
| 236 | M. C. Cole | La Bolsa Chica | N-3 | 1900 | Bored, 2-inch | 16 | 16 | 60 | | | Artesian | | | Irrigation | 6 |
| 237 | do | do | N-3 | 1895 | Bored, 7-inch | 17 | 17 | 130 | | | do | | | do | 2 |
| 238 | do | do | N-3 | 1895 | do | 19 | 19 | 131 | | | do | | | do | 11 |
| 239 | do | do | N-3 | 1904 | Bored, 7-inch, 184 feet; 4-inch, 125 feet. | 30 | 30 | 309 | 25 | 70 | do | | | Irrigation; domestic. | 12 |
| 240 | do | do | N-3 | | Bored, 7-inch | 30 | 30 | 325 | | | Wind | | | Stock | |
| 241 | Frank Lintner | do | N-3 | 1892 | Bored, 4-inch | 16 | 16 | 97 | 26 | 64 | Artesian | $60.00 | | Domestic; irrigation. | 14 |
| 242 | H. S. Brakebill | do | N-3 | 1899 | do | 16 | 16 | 69 | 26 | 65 | do | 45.00 | | Irrigation | 18 |
| 243 | do | do | N-3 | 1896 | Bored 7-inch | 16 | 16 | 49 | | | do | | | do | 4 |
| 244 | John Lawrence | do | N-3 | 1899 | Bored, 3-inch | 16 | 16 | 49 | 25 | 65 | do | | | do | Small. |
| 245 | Frank Lintner | do | N-3 | 1902 | Bored, 2-inch | 15 | 15 | 72 | | | do | 32.00 | | do | 5 |
| 246 | do | do | N-3 | 1899 | Bored, 4-inch | 16 | 16 | 97 | | | do | 60.00 | | do | †14 |
| 247 | do | do | N-3 | 1897 | do | 16 | 16 | 68 | 26 | 64 | do | 45.00 | | do | 4 |
| 248 | B. F. Houser | do | N-3 | | Bored, 3-inch | 19 | 19 | | | | do | | | do | Small. |
| 249 | do | do | N-3 | | Bored, 4-inch | 18 | 18 | 65 | 27 | 64 | do | | | do | 1 |
| 250 | S. G. Huff | do | N-4 | 1898 | Bored, 3-inch | 15 | 15 | 46 | | | do | 28.00 | | do | Small. |
| 251 | W. H. Hicks | do | N-4 | 1898 | Hydraulic, 2-inch | 22 | 22 | 85 | | | Hand | | | Domestic; stock | |
| 252 | Huntington Beach Co. | Las Bolsas | N-5 | 1898 | Bored, 7-inch | 60 | 60 | 220 | 37 | | Wind | | | Stock; irrigation | |
| 254 | do | do | N-7 | | Bored, 10-inch | 30 | 30 | 200? | 35 | | Wind, gas | | | Domestic | |
| 256 | Bolsa Land Co. (gun club). | do | L-3 | | Bored, 2-inch | 10 | 10 | 300 | 83 | 66 | Artesian | | | | Small. |
| 257 | Lometa Land Co. | La Bolsa Chica | K-3 | | Bored, 7-inch | 30 | 30 | 130 | 20 | | Wind | | | Domestic; stock | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 258 | Sunset Beach Co. | do | K-3 | 1901 | do | 18 | 18 | 181 | 22 | 68 | Artesian | Not used | | 7 |
| 258a | do | do | K-3 | 1901 | do | 18 | 18 | 181 | 22 | 68 | do | do | | 5 |
| 259 | Bolsa Land Co. (gun club). | do | N-4 | | Bored, 2-inch | 12 | 12 | 64 | 26 | 65 | do | Stock; domestic | | 4 |
| 260 | do | do | N-4 | | Hydraulic, 2-inch. | 12 | 12 | 58 | | | do | Irrigation | | 4 |
| 261 | do | do | N-4 | 1901 | do | 14 | 14 | 42 | | | do | do | | 5 |
| 262 | do | do | N-4 | | do | 14 | 14 | 51 | 23 | 66 | do | do | | |
| 263 | do | do | N-4 | | do | 14 | 14 | 52 | 22 | 66 | do | Duck pond | | 5 |
| 264 | do | do | N-4 | | do | 14 | 14 | | 25 | 64 | do | do | | 4 |
| 265 | do | do | M-4 | | do | 12 | 12 | 52 | 23 | 66 | do | do | | 5 |
| 266 | do | do | M-4 | | do | 12 | 12 | 46 | | 68 | do | do | | 4 |
| 267 | do | do | M-4 | | do | 12 | 12 | 68 | 21 | 64 | do | do | | 4 |
| 268 | do | do | M-4 | | do | 12 | 12 | 67 | 23 | 68 | do | do | | 2 |
| 269 | do | do | M-4 | | do | 12 | 12 | 84 | | 66 | do | do | | 2 |
| 270 | do | do | M-4 | | do | 12 | 12 | 65 | 22 | 66 | do | do | | 6 |
| 271 | do | do | M-4 | | Bored, 2-inch | 12 | 12 | 60 | 25 | 65 | do | do | | 7 |
| 272 | do | do | M-4 | | Hydraulic, 2-inch. | 12 | 12 | 55 | 23 | 64 | do | do | | 6 |
| 273 | do | do | M-4 | | do | 12 | 12 | 65 | 23 | 64 | do | do | | 4 |
| 274 | do | do | M-4 | | do | 12 | 12 | 63 | 24 | 64 | do | do | | 4 |
| 275 | do | do | M-4 | | Bored, 2-inch | | | 59 | 23 | 65 | do | do | | 6 |
| 276 | do | do | M-3 | | Hydraulic, 2-inch. | 12 | 12 | 54 | 24 | 66 | do | do | | 7 |
| 277 | do | do | M-3 | | Bored, 2-inch | 12 | 12 | 54 | | | do | do | | 7 |
| 278 | do | do | M-3 | | Hydraulic, 2-inch. | 12 | 12 | 68 | 25 | 67 | do | do | | 8 |
| 279 | do | do | M-4 | | do | 12 | 12 | 57 | | | do | do | | 6 |
| 281 | do | do | M-4 | | do | 12 | 12 | 54 | 24 | 65 | do | do | | 6 |
| 282 | do | do | M-3 | | do | 12 | 12 | 43 | 28 | 68 | do | do | | 6 |
| 283 | do | do | M-3 | | do | 13 | 13 | 43 | 33 | 66 | do | do | | 7 |
| 284 | J. H. Cole | do | L-3 | | Bored, 2-inch | 14 | 14 | 55 | 25 | 68 | do | Irrigation | | 4 |
| 285 | Lometa Land and Water Co. (gun club). | do | L-2 | 1903 | Hydraulic, 4-inch. | 15 | 15 | | | | do | Duck pond | | 8 |
| 286 | do | do | L-2 | 1903 | do | 15 | 15 | | | | do | do | | 14 |
| 287 | do | do | L-2 | 1903 | do | 15 | 15 | | | | do | do | | 4 |
| 288 | do | do | L-3 | 1903 | do | 15 | 15 | | | | do | do | | |
| 289 | do | do | L-3 | 1903 | do | 15 | 15 | | | | do | do | | |
| 290 | do | do | L-3 | 1903 | Hydraulic, 2-inch. | 15 | 15 | | 26 | 66 | do | do | | 5 |
| 291 | do | do | L-3 | 1903 | Hydraulic, 4-inch. | 15 | 15 | | | | do | do | | |

*Wells in Las Bolsas quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water. | Depth of well. | Solids per 100,000. | Temperature of water. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Feet.* | *Feet.* | *Feet.* | | °*F.* | | | | | *Miner's inches.* |
| 292 | Lometa Land and Water Co. (gun club). | La Bolsa Chica | L-2 | 1903 | Hydraulic, 4-inch. | 15 | 15 | | | | Artesian | | | Duck pond | |
| 293 | do | do | L-2 | 1903 | do | 15 | 15 | | 26 | 66 | do | | | do | |
| 294 | do | do | L-2 | 1903 | do | 15 | 15 | | 27 | 66 | do | | | do | |
| 295 | do | do | L-2 | 1903 | Hydraulic, 3-inch. | 15 | 15 | | | | do | | | do | |
| 296 | do | do | L-2 | 1903 | Hydraulic, 4-inch. | 15 | 15 | | | | do | | | do | |
| 297 | F. Dimock | do | K-1 | 1898 | Bored, 2-inch | 20 | 20 | 124 | 26 | 66 | do | | | Domestic; irrigation. | 6 |
| 298 | do | do | K-1 | 1902 | do | 22 | 22 | 152 | 31 | | do | | | Irrigation | 7 |
| 299 | do | do | L-2 | 1903 | do | 22 | 22 | 190 | | | do | | | do | |
| 300 | | Los Alamitos | J-1 | | Bored, 3-inch | 25 | 25 | 300+ | 19 | 76 | do | | | Stock | 9 |
| 301 | Anaheim Beach Co | do | I-1 | | Dug, 4½ by 4½ foot. | 15 | 15 | 12 | 68 | 63 | Hand | | | Domestic; stock. | |
| 302 | do | do | I-1 | | Bored, 7-inch | 15 | 15 | 100 | 200+ | 63 | | | | Not used | |

# INDEX.


Page.

Agricultural ditch, data concerning ..... 18
Anaheim, average rainfall at ..... 28, 32
  average rainfall at, departures from, chart showing ..... 29
  rainfall at, table of ..... 28
  water level at, variation in, figure showing ..... 34
Arroyo ditch, data concerning ..... 16-17
Arroyo Ditch and Water Co., organization of ..... 16
Artesian areas, diminution of ..... 21-22, 35
  extent of ..... 21-22
  location of, maps showing ..... Pocket.
  theory of ..... 20-21
Baldwin's ditch, flow of ..... 13
Ballona artesian area, location and cause of ..... 21
Banta, P., work of ..... 16
Banta ditch, data concerning ..... 13, 15, 16
Bennett, S. G., flow measurement by ..... 16
Bolsa drainage district, organization of ..... 18-19
Canals in Downey and Las Bolsas quadrangles, location of, map showing ..... Pocket.
Cate, J. W., work of ..... 14
Cate ditch, data concerning ..... 13, 14-15
Cate Ditch Water Co., organization of ..... 14
Clapp, W. B., flow measurements by ..... 16, 17
Coastal plain, extent and character of ..... 10
  view on ..... 10
Contours, hydrographic, explanation of ..... 36
  map showing ..... Pocket.
Crops, character of ..... 9, 11-12
Downey quadrangle, artesian area in ..... 21
  artesian area in, decrease in ..... 21-22, 34-35
  irrigated lands in ..... 36
  location of ..... 11
  maps of ..... Pocket.
  wells in, data concerning ..... 22-23, 40-149
Drainage districts in Downey and Las Bolsas quadrangles, map showing ..... Pocket.
East Whittier Water Co., system of ..... 18
Electrolytic bridge, use of ..... 37
Fisk, A. J., work of ..... 39
Foster ditch, data concerning ..... 17
Furstenfeld, E. R., work of ..... 39
Gage ditch. *See* Foster ditch.
Hall, W. H., on southern California ditches. 14
Hamlin, Homer, acknowledgments to ..... 39
Hansen, A. C., work of ..... 39
Irrigation, necessity for and growth of ..... 10
  systems of ..... 13-18
Lamb, W. B., work of ..... 18
Lands, irrigable, value of ..... 10

Page.

Lands, irrigated, in Downey and Las Bolsas quadrangles, map showing .. Pocket.
Las Bolsas quadrangle, artesian areas in ..... 21
  irrigated lands in ..... 36
  location of ..... 11
  maps of ..... Pocket.
  wells in, data concerning ..... 22-23, 149-160
Lippincott, J. B., acknowledgments to ..... 39
Little Lake ditch, data concerning ..... 18
Long Beach, water supply of ..... 18
Los Alamitos Beach, water supply of ..... 18
Los Angeles, average rainfall at ..... 28, 30-34
  average rainfall at, departures from, chart showing ..... 33
  rainfall at, table of ..... 32
Los Angeles River, character of ..... 20
  water supply from ..... 12-13, 19
Los Nietos ditch, data concerning ..... 13, 15, 16
Map showing location of irrigated lands, canals, drainage districts, and pumping plants ..... Pocket.
  showing location of wells, artesian areas, and water levels ..... Pocket.
Maps, descriptions of ..... 35-39
Mesmer, Louis, on soils of Los Angeles area. 11
Miner's inch, equivalents of ..... 15
Neff, J. B., records by ..... 27
Paso de Bartolo, river diversion at ..... 13
Pio Pico, work of ..... 16
Puente Hills, water supply from ..... 19
Pumping, necessity for ..... 25
Pumping plants in Downey and Las Bolsas quadrangles, location of, map showing ..... Pocket.
Quadrangle, definition of ..... 9
Rainfall at Anaheim ..... 28, 29, 32
  at Los Angeles ..... 28, 30-33
  at San Bernardino ..... 28-32
Rainfall, average, departures from ..... 30-32
  average, departures from, charts showing ..... 29, 31, 33
Ranchito ditch. *See* Standifer ditch.
Rincon ditch, data concerning ..... 13, 14
Rincon Irrigation Co., organization of ..... 14
Rio Hondo, discharge of ..... 13, 17
Riverside artesian basin, location of, and cause for ..... 21
San Antonio ditch, data concerning ..... 17
San Bernardino, average rainfall at ..... 28-32
  average rainfall at, departures from, chart showing ..... 31
  rainfall at, table of ..... 30
San Bernardino artesian belt, location and cause of ..... 21
San Gabriel River, character of ..... 20

Page.
San Gabriel River, diversion of ..... 18
water supply from..... 12-13, 19
Santa Ana River, character of..... 20-21
water supply from..... 12-13, 19
Section Line ditch, data concerning ..... 18
Sheep Creek ditch, flow of ..... 13
Soils, character of ..... 11
Standifer ditch, data concerning..... 13, 15
Temple ditch, flow of ..... 13
Water, distribution of, method of ..... 15, 16
supply of ..... 12-13
Water, underground, character of ..... 39
development of..... 10, 22-24, 35
effects of..... 23-24, 27, 35
distribution of..... 20-22
extent of ..... 24
level of, map showing ..... Pocket.
variations in..... 26-27, 32-35
variations in, figures showing... 29, 31, 34

Page.
Water, underground, permanence of..... 24-35
solids in, determination of..... 37-38
distribution of, map showing..... 38
sources of..... 12-13, 19-20, 24, 35
supply of ..... 35
interference with..... 13, 23-24
*See also* Contours, hydrographic.
Wells, typical, views of..... 22
Wells in Downey quadrangle, data concerning ..... 22-23, 40-149
location of, map showing..... Pocket.
in Las Bolsas quadrangle, data concerning ..... 22-23, 149-160
location of, map showing..... Pocket.
in region, number of ..... 22
investigation of ..... 36-37
White, W. N., work of..... 39
Whittier, coastal plain near, view of..... 10
water supply of..... 18

O

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Correspondence should be addressed to

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AUGUST, 1905.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

# DEVELOPMENT OF UNDERGROUND WATERS

IN THE

# WESTERN COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA

BY

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# CONTENTS.


| | Page |
|---|---|
| Letter of transmittal | 7 |
| Introduction | 9 |
| The coastal plain | 10 |
| Soils and crops | 11 |
| Water supply | 12 |
| Underground water | 14 |
| Source | 14 |
| Distribution | 14 |
| Permanence of the supply | 16 |
| Description of maps and tables | 18 |
| Acknowledgments | 21 |
| Well data | 22 |
| Index | 109 |

# ILLUSTRATIONS.


Page.

PLATE I. Artesian areas and hydrographic contours of the coastal plain of southern California ..... Pocket.

II. Salt marshes, sand dunes, and sandpits near the mouth of Ballona Creek. 10

III. *A*, Bluffs cut in the alluvial bench lands which form the inner edge of the coastal plain; *B*, Characteristic view of the alluvium which forms the Santa Monica bench lands ..... 12

IV. Inner edge of the coastal plain and limiting hills between Hollywood and Los Angeles ..... 14

V. Map showing wells, artesian areas, and water levels in the Redondo quadrangle ..... Pocket.

VI. Map showing wells, artesian areas, and water levels in the Santa Monica quadrangle ..... Pocket.

VII. Map of irrigated lands, pumping plants, and distributing systems in the Redondo quadrangle ..... Pocket.

VIII. Map of irrigated lands, pumping plants, and distributing systems in the Santa Monica quadrangle ..... Pocket.

FIG. 1. Map showing approximate amounts of dissolved solids in underground waters of the coastal plain region of southern California ..... 20

# LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
*Washington, D. C., January 12, 1905.*

SIR: I transmit a report entitled "The Development of Underground Waters in the Western Coastal Plain Region of Southern California," prepared by Mr. W. C. Mendenhall, under the direction of Mr. N. H. Darton, and recommend that it be published as a Water-Supply and Irrigation Paper.

This paper is similar to two recently published on the eastern and central portions of the coastal plain of southern California. These papers contain a list of nearly all the wells in this section of the State, and such data as to water levels, irrigation systems, and irrigated lands as could be collected by a careful canvass. In addition each paper contains a brief discussion of the conditions affecting the underground waters in the particular section of which it treats.

The studies, a part of whose results are being made available in this way, are planned to cover all the important water-bearing lands of the valley of southern California. In most instances the facts gathered concerning the wells and the distributing systems will be supplemented by a study of the local geology, in so far as it controls the amount, distribution, and circulation of the ground waters. The hydrographic data and the geologic data will then be discussed and issued together in one report. In the coastal plain area, however, the geologic conditions being relatively simple and the hydrographic data being large in volume and of paramount importance, it is deemed best to issue the latter at once, rather than to delay it pending the working out more fully of the comparatively unimportant geologic problems. Therefore the tables and maps are presented here for the consideration of water users, with a comparatively brief text, which is chiefly descriptive, but which includes a discussion of the effects of development and drought in bringing about those changes in water levels and in the outlines of artesian areas which have been most marked within the last five or six years.

Very respectfully,

F. H. NEWELL,
*Chief Engineer.*

Hon. CHARLES D. WALCOTT,
*Director United States Geological Survey.*

# DEVELOPMENT OF UNDERGROUND WATERS IN THE WESTERN COASTAL PLAIN REGION OF SOUTHERN CALIFORNIA.

By W. C. MENDENHALL.

## INTRODUCTION.

The greater part of the coastal plain of southern California is included in the Anaheim, Santa Ana, Downey, Las Bolsas, Santa Monica, and Redondo quadrangles[a] of the United States Geological Survey, and all of it is in Orange and Los Angeles counties. For convenience of treatment and discussion the coastal plain has been divided into an eastern, a central, and a western section, each section including two quadrangles. The eastern and central sections are described in Water-Supply Papers Nos. 137 and 138.

The westernmost section, which includes the Redondo quadrangle and the south half of the Santa Monica quadrangle, is described in this paper. The more important data are presented in the form of tables and maps; the tables giving the essential facts regarding each well examined, the maps showing graphically the irrigated areas, the attitude of the water plane, the extent and position of the past and present artesian areas, and the zones of relative purity of the ground waters.

In this area, which includes the largest body of water-bearing land, the largest artesian basin, and the most extensive diversified farming district of the southern part of the State, the development of underground waters for domestic purposes and irrigation has been under way for twenty-five years, but has been especially marked during the past decade.

By the valley of southern California is meant that lowland area that is limited on the north by the San Gabriel Range and is separated from the Mohave and Colorado deserts on the east by the San Bernardino and San Jacinto mountains. Toward the west it is open to the

[a] A quadrangle is the unit of survey adopted by the United States Geological Survey for the topographic and geologic atlas of the United States. It is a rectangular area 15 minutes, 30 minutes, or 1 degree in extent each way, bounded by parallels and meridians, and having an area of one-sixteenth, one-quarter, or 1 square degree. The quadrangles disregard political boundaries, such as those of States, counties, and townships. To each is given the name of some well-known place or feature within its limits. A sheet is a topographic map of one of the above areas.

Pacific, and on the south its limits are irregular and to a certain degree indefinite, the minor valleys into which the major valley divides in this direction gradually contracting and eventually practically disappearing in the general heights of the Sierra Madre.

This valley is more populous, is more intensely cultivated, and represents more concentrated wealth than any similar area in the entire Southwest. The basis for its wealth is its climate, which depends upon its physical geography and its latitude. Its southern situation is responsible for its moderately high mean annual temperature of about 62°; and the fact that it is open to the Pacific and is separated from the deserts to the north and east by high mountain ranges not only insures an equable distribution throughout the year of the mean temperature, but is an admirable provision for greater rainfall than is usual so far south on the Pacific coast. This combination of mild temperature and sufficient rainfall to provide for the cultivation of a large acreage, but not to destroy the beneficial effects of semiaridity with its large proportion of bright days and its dry air. makes the region most attractive as a place of residence. Furthermore, the soils are generally well disintegrated arid-land soils, not leached of their valuable soluble fertilizing constituents, so that with the artificial application of water they prove highly productive.

The valley of southern California is divided by the Santa Ana Mountains and their extension, the Puente Hills, into the coastal plain and the interior valley, each with its own minor peculiarities of soil and climate, and each exhibiting certain special phases of the problem which is common to southern California as to all arid and semiarid regions—the problem of water supply.

## THE COASTAL PLAIN.

The coastal plain as a whole (see Pl. I) is about 50 miles in length in a northwest-southeast direction, and from 15 to 20 miles in width from the Pacific Ocean to the base of the Puente Hills and Santa Ana Mountains. It has an area of about 775 square miles. It is in general a region of low relief, and slopes gently seaward from an elevation of 200 or 300 feet along the inner edge to the salt marshes and sand dunes which border the Pacific. (Pl. II.) The chief interruptions to its level surface are San Pedro Hill, which rises distinctly above it but is not to be regarded as in any sense a part of it, and the low ridge which extends southeastward from the vicinity of Palms toward Huntington Beach. The most prominent heights along this ridge are the point just southeast of Palms, and Dominguez and Los Cerritos hills, 517, 195, and 364 feet in elevation, respectively. This ridge divides the coastal plain into an eastern and western section, alike as to climate, similar as to soils, but distinct as to underground conditions and the quantity and disposition of the ground waters.

SALT MARSHES, SAND DUNES, AND SAND SPITS.

Near mouth of Ballona Creek.

The inner edge of the plain is generally bench land, which contours the higher mountains back of it, forms bluffs (Pl. III, *A*) where the mountains approach the coast, and is dissected somewhat by the canyons of the small streams which cross it. These gullied benches are especially conspicuous back of Santa Monica and along the south base of the Santa Monica Mountains. Here they are composed of alluvium—stream-deposited sands, gravels, and clays—in contrast to the marine deposits which make up much of the coastal plain proper.

The eastern and central sections of the coastal plain, which have been discussed in Water-Supply Papers Nos. 137 and 138, include the greater part of the coastal plain artesian belt (Pl. I) and the lower courses of Los Angeles, San Gabriel, and Santa Ana rivers. The western section described here is crossed by none of the larger streams of the valley, and includes only the northwestern narrower part of the artesian area. It therefore contains a somewhat larger proportion of dry lands than the central and eastern areas. Its drainage generally is indefinite and ill defined, the valley of Ballona Creek being the only clearly marked drainage system in it. Along the coast is a belt of sand dunes which, in the section north of San Pedro Hill, extend inland for 2 miles in some instances, although these inner dunes are not now active.

South of Gardena is a depressed area without a surface outlet which has contained a lake 2 or 3 miles long during exceptionally wet years. At present this depression is dry. Other smaller pits are distributed along the old sand-dune belt back of the stretch of coast extending from Playa del Rey to Redondo.

## SOILS AND CROPS.

The soils of this western section are generally fine in texture, contrasting strongly in this respect with many of the foothill soils of the valley farther inland nearer the high ranges. The dark loams with a notable percentage of humus are practically confined to the valley of Ballona Creek, to the marshes which extend northward from its mouth, and to an area which overlies the present or the original artesian basin, and is situated just south of the city of Los Angeles, in the vicinity of Slauson and Green Meadows. At a few points in the Ballona Valley these soils are slightly alkaline, but where free from injurious salts they are very fertile. Their fertilizing admixture of vegetable matter is due to the fact that they are or have been moist lands covered with a dense natural growth whose decay has yielded humus.

The upland soils are almost invariably sandy, although the sand sometimes contains a noticeable percentage of clay. The soils in the region extending from Inglewood to Wilmington are of this character, the purer and coarser sands lying nearer the coast and the clay

element proving more abundant farther inland. The uplands, which form the foothills of the Santa Monica Mountains from Sherman to the sea, are composed of alluvial materials washed from the mountains, but the alluvium (Pl. III, *B*) is fine because the mountains are low; and the proportion of clay in it is large, as the mountains themselves contain a considerable proportion of shale, which forms clay at once upon disintegration.

Along the foothills north and west of the city of Los Angeles (Pl. IV), and toward Hollywood, there is a thin blanket of soil formed in place by the disintegration of the underlying shales; similar but usually finer soils are found on the northern slopes of San Pedro Hill.

The dry-land crops, here as elsewhere on the coastal plain, are barley, raised for hay and grain; olives, occasionally cultivated in small groves; and on the Santa Monica bench lands, beans. Beans are raised on thousands of acres between Hollywood and the coast and have proved very profitable. Groves of eucalyptus grow in many places, having been planted for fuel and for wind-breaks. These trees thrive better in the moister lands, but will grow in very dry locations. The diversity which is so usual on the coastal plain in the irrigated-land crops is not lacking in this region. South of Los Angeles there is a large acreage in gardens, whose products are sold in the city markets. Vegetables, berries, and small fruits are produced here in large quantities. Dairying and the raising of corn, alfalfa, and walnuts are practiced in the neighborhood of Green Meadows, and in the lower Ballona Creek Valley. Some citrus groves are found about Hollywood and in the lower lands south of Los Angeles, lemons being grown with particular success in the Cahuenga Valley. Oranges are not grown so extensively nor so successfully as on the higher, warmer lands farther inland.

## WATER SUPPLY.

All of the ground waters as well as all of the surface waters of southern California have their ultimate source in the rainfall of the tributary drainage basins. This rainfall is greatest in the mountainous areas and least in the lowlands at a distance from the mountains, but as the streams gather the mountain floods and carry them seaward across the lower areas, these are benefited by the distant precipitation.

So the coastal plain, across which lie the lower courses of the three largest rivers of this part of the State, is the region most favorably situated from the point of view of water supply, the Los Angeles, San Gabriel, and Santa Ana watersheds each contributing to it. That part of the coastal plain which is near the lower courses of these streams is most favorably situated to benefit by the flow through them. Before the water can reach the more distant parts of the

*A.* BLUFFS IN ALLUVIAL BENCH LANDS.

Inner edge of coastal plain.

*B.* CHARACTERISTIC ALLUVIUM OF SANTA MONICA BENCH LANDS.

plain it must percolate some distance underground, and even if its course is through very pervious materials the passage requires time, the capacity of all nearer gravels must be satisfied before it can be made, and all intervening developments lessen its amount. The coastal plain as a whole is the best watered large area and the largest well-watered area in the valley of southern California, but its western section is not so well situated relative to the principal sources as are the central and eastern sections. None of the larger streams cross it, although Los Angeles River flows near it and certainly contributes to its underground supplies.

Except for the flood waters contributed by Los Angeles River, this region, which includes the Redondo and the south half of the Santa Monica quadrangles, receives no water from the high mountains, which are so important a source of surface and of subsurface waters everywhere. With the exception of this contribution, it is dependent upon local rainfall and the comparatively limited run-off from the south slope of the Santa Monica Mountains.

Since there are no large flowing streams in the area, there are no very important surface systems of irrigation, such as originally utilized the flowing waters of Los Angeles River before the needs of the city absorbed it all, and such as now distribute the waters of the San Gabriel below the Paso de Bartolo and of the Santa Ana below Bedrock Canyon. The most important ditches are those that distribute well water, as does the flume of the Artesian Water Company that serves lands in the lower Ballona Creek Valley.

This company owns water-bearing lands near Cienega station, on the Santa Monica branch of the Southern Pacific Railroad, in which about 15 wells have been bored. The water from these wells, amounting to about 100 miner's inches, is conducted by a redwood flume, 8 or 9 miles long, 3¼ feet wide, and 2 feet deep, to the lands served in the middle and lower Ballona Creek Valley in the vicinity of Palms. The company was organized in 1900, with a capital stock of $250,000. The stock is not held by irrigators, but the company sells the water to them at a price of $10 per head for a 24-hour run, equal to 0.4 cent per hour-inch. For smaller quantities of water, 30 cents per hour for one-half head is charged, an advance of 50 per cent over the rates for larger quantities. The cost of the wells and the flume is reported at $50,000, and the total number of acres irrigated in 1904 is given as 750—400 in beans and the remainder in alfalfa and walnuts, there being but a small proportion of the latter.

Other shorter ditches are used to distribute the waters of Ballona Creek, and many of the pumping plants are connected with permanent wooden flumes or cement systems. Still other ditches distribute sewage from the Los Angeles outfall sewer or directly from the city system.

The greater part of the irrigation in the two quadrangles, however, is accomplished by means of the individual pumping plants, which are abundant throughout the lowlands south and southwest of Los Angeles, in an area originally artesian. A number of rather extensive local systems of this character have also been developed farther out upon the coastal plain in the vicinity of Gardena and Moneta.

## UNDERGROUND WATER.

### SOURCE.

Excluding the waters in the rock basins, the ultimate sources of all the ground waters are in the drainage areas of the streams which are tributary to the region. Thus the underground waters of the area north of the low ridge which divides the coastal plain are largely supplied by the drainage basin of Los Angeles River. When this stream discharges upon the coastal plain, after leaving the narrows at Los Angeles, its waters sink, and, spreading into a broad indefinite sheet, join the waters of the other rivers which flow out upon the coastal plain. Thus the coastal plain artesian basin is supplied. It is altogether probable that the moist lands about the station of Cienega, on the Southern Pacific Railroad, at the head of Ballona Creek, are thus supplied in large part by Los Angeles River water, and that the artesian wells in this neighborhood are also supplied largely by it, since it is the nearest of the greater coastal plain rivers.

It is not possible in general to tell where the boundary lies between those waters in an underground basin which are supplied from one source and those supplied from another, since the waters soon mingle and a definite boundary ceases to exist. Their behavior may very well be compared with that of two surface streams which unite. For a short distance below the junction the waters from each may be perfectly distinct, but the band of mingled waters along a median line becomes gradually broader until it extends from bank to bank. Then it can no longer be said of the water of any part of the stream that it is contributed exclusively by this or that tributary, since each has furnished a portion of it. The mingling of underground waters from distinct sources is precisely similar in character, but the process is much slower, since the rate of percolation is not as great as that of surface flow.

### DISTRIBUTION OF UNDERGROUND WATER.

The interrupted ridge which extends northwest from Huntington Beach to the vicinity of Palms divides the coastal plain into an eastern and a western portion. Of these, the eastern portion has much the greater area. It includes the bigger part of the Downey, Anaheim, and Santa Ana quadrangles, while the western section occupies much of the Redondo quadrangle and a part of the Santa

INNER EDGE OF COASTAL PLAIN AND LIMITING HILLS.

Between Hollywood and Los Angeles.

Monica quadrangle. The ridge which separates these two sections is not a surface feature merely. It seems to be the surface expression of a broad fold in the sands and clays of the coastal plain—a fold that acts as a dam to waters seeking a way seaward beneath the surface, checking their course and tending to force them toward the surface in order to pass the obstruction. In consequence, ground-water levels are much higher above this ridge than below it, as would be true of a surface dam, and the chief artesian basin of the coastal plain, as, indeed, of southern California, owes its existence to it. This is the great basin (Pl. I), originally nearly 300 square miles in area, which stretches from below Santa Ana to the vicinity of Sherman.

Only the narrower northern end of this basin lies within the western coastal plain area, and the greater part of this western end no longer yields flowing water. (Pls. V and VI.) A few wells still flow in that part of it which lies 3 or 4 miles directly east of the Palms, and there is another small group of flowing wells in the vicinity of Sherman. Throughout the remainder of that part of the basin which is included in the Redondo and Santa Monica quadrangles, although water lies within easy pumping distance of the surface, the cheaper artesian waters can no longer be secured.

Another effect of this anticlinal ridge is to bring about great regularity in the ground-water levels above it. The hydrographic contours here indicate a moderate and generally regular slope of the water table. Below the ridge the slope is much less uniform, while within the broad area occupied by the ridge itself water levels are too erratic to be mapped with the slender evidence available.

Some of the winter flood waters, flowing as surface streams, escape across this ridge and reach the lower, drier lands toward the sea, where they are in part absorbed. It is probable also that, although this fold in the coastal plain clays and gravels acts as a dam, it is not uniformly impervious, and underground waters probably pass it to a certain limited extent. Such waters are contributed to the subsurface supply below the ridge, where they may be pumped.

Near the mouth of Ballona Creek is another small artesian basin, a few wells there tapping sand or gravel bodies which yield flowing water. Another small basin in the vicinity of Colegrove also yields flowing water, but from a consolidated sandstone of Tertiary age instead of from the loose sands and gravels which are the usual water-bearing media. These wells were bored for oil and are in some instances 1,000 feet or more in depth; not all equally deep wells in the vicinity, however, struck water under sufficient pressure to flow. It is not unusual to secure small flows from wells drilled for oil in the Tertiary beds of the Coast Range and foothills, but the yield is generally inferior to that from wells in the unconsolidated Pleistocene material of the

lowlands, and the water is almost invariably of poorer quality, since the Tertiary sands and shales are heavily impregnated with alkali salts. These rock waters, like the more abundant gravel waters, have their ultimate source in the rainfall; but, unlike the gravel waters, their circulation is not necessarily limited by drainage basins, since the rock structures favorable to percolation may extend from one drainage basin through an intervening range of hills to a neighboring basin.

These structures could be determined by detailed work and the underground courses of such waters and the intake at which they originate predicted, but as they are very limited in value and amount the results would not justify the work and expense. In the presence of so much freer sources they may in most cases be ignored.

## PERMANENCE OF UNDERGROUND SUPPLY.

In all of the important basins of southern California during the last ten years there has been a general if varying fall in ground-water levels, a shrinkage of artesian areas, and a general reduction of yield from those artesian wells which continue to flow.

*Rainfall, in inches, at Los Angeles, Cal.*

| Year. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1877-78 | 0.00 | 0.00 | 0.00 | 0.86 | 0.45 | 3.93 | 3.33 | 7.68 | 2.57 | 1.71 | 0.66 | 0.07 | 21.26 |
| 1878-79 | .00 | T. | .00 | .14 | T. | 4.70 | 3.59 | .97 | .49 | 1.19 | .24 | .03 | 11.35 |
| 1879-80 | .00 | .00 | .00 | .93 | 3.44 | 6.53 | 1.33 | 1.56 | 1.45 | 5.06 | .04 | .00 | 20.34 |
| 1880-81 | T. | T. | .00 | .14 | .67 | 8.40 | 1.43 | .36 | 1.66 | .46 | .01 | .00 | 13.13 |
| 1881-82 | .00 | T. | T. | .82 | .27 | .52 | 1.01 | 2.66 | 2.66 | 1.83 | .63 | T. | 10.40 |
| 1882-83 | .00 | .00 | T. | .05 | 1.82 | .08 | 1.62 | 3.47 | 2.87 | .15 | 2.02 | .03 | 12.11 |
| 1883-84 | T. | .00 | .00 | 1.42 | .00 | 2.56 | 3.15 | 13.37 | 12.36 | 3.54 | .34 | 1.39 | 38.13 |
| 1884-85 | T. | T | T. | .30 | 1.06 | 4.64 | 1.05 | T. | .01 | 2.00 | .06 | T. | 9.12 |
| 1885-86 | T. | T. | T. | .26 | 5.52 | 1.63 | 7.72 | 1.38 | 2.50 | 3.29 | 00 | .01 | 22.31 |
| 1886-87 | .24 | .21 | .00 | .01 | 1.18 | .18 | 0.20 | 9.25 | .24 | 2.30 | .20 | .04 | 14.05 |
| 1887-88 | .07 | .00 | .15 | .12 | .78 | 2.67 | 6.03 | .77 | 3.15 | .11 | .02 | T. | 13.87 |
| 1888-89 | .03 | .08 | T. | .36 | 4.01 | 6.26 | .25 | .92 | 6.48 | .27 | .62 | .00 | 19.28 |
| 1889-90 | .00 | .61 | .00 | 6.95 | 1.35 | 15.80 | 7.83 | 1.36 | .66 | .22 | .03 | .02 | 34.83 |
| 1890-91 | .00 | .03 | .06 | .03 | .13 | 2.32 | .25 | 8.56 | .41 | .26 | .31 | .00 | 12.36 |
| 1891-92 | T. | .00 | .06 | .00 | .00 | 1.99 | .88 | 3.19 | 3.39 | .22 | 2.06 | .06 | 11.85 |
| 1892-93 | .00 | .01 | .00 | .33 | 4.40 | 4.18 | 6.29 | 2.27 | 8.52 | .19 | .06 | .03 | 26.28 |
| 1893-94 | .00 | .00 | T. | .75 | .20 | 3.65 | .94 | .49 | .37 | .13 | .20 | T. | 6.73 |
| 1894-95 | T. | .01 | .73 | .02 | .00 | 4.62 | 5.84 | .46 | 3.77 | .46 | .19 | .01 | 16.11 |
| 1895-96 | T. | T. | T. | .24 | .80 | .78 | 3.23 | T. | 2.97 | .19 | .30 | T. | 8.51 |
| 1896-97 | .02 | .01 | T. | 1.30 | 1.66 | 2.12 | 3.70 | 5.62 | 2.31 | .02 | .10 | T. | 16.86 |
| 1897-98 | T. | .00 | .00 | 2.47 | .01 | .05 | 1.26 | .51 | .98 | .03 | 1.75 | T. | 7.06 |
| 1898-99 | .07 | T. | .02 | .09 | T. | .12 | 2.64 | .04 | 1.81 | .18 | .04 | .58 | 5.59 |
| 1899-1900 | .00 | .01 | T. | 1.59 | .90 | .90 | 1.17 | T. | .99 | .54 | 1.81 | T. | 7.91 |
| 1900-1901 | T. | T. | T. | .26 | 6.53 | T. | 2.49 | 4.38 | .45 | .68 | 1.50 | T. | 16.29 |
| 1901-02 | T. | .09 | .03 | 1.88 | .46 | T. | 1.62 | 3.35 | 2.98 | .16 | .03 | T. | 10.60 |
| 1902-03 | T. | T. | T. | .40 | 2.08 | 2.50 | 2.10 | 1.52 | 6.93 | 3.77 | T. | .02 | 19.32 |
| 1903-04 | .00 | T. | .43 | T. | 0 | T. | .14 | 2.68 | 4.50 | .97 | T. | T. | 8.72 |

Average twenty-seven years, 15.35 inches.

The last ten years have been a period of low rainfall, the average at Los Angeles for the period being 25 per cent below the normal there. As a result the ground waters have been diminished by the decrease in the floods which supply them and by the increase in the drafts made upon them in order to make up the deficiency in stream flow. Hence an mportant part of the admitted shrinkage is justly chargeable to the dry period. But in some localities constant measurements on the water plane show that during the winters of 1900–1901 and 1902–3, during both of which the rainfall was above the average, the water level continued to fall, although at a much less rapid rate than during other drier years. At these places, therefore, it is evident that there should be no further increase of the drafts upon the underground waters, and that the reclaiming of lands from these as a source should cease.

In the western coastal plain area drafts have not yet become excessive, the wells being as yet relatively few in number.

In the Santa Monica quadrangle there are only about 25 flowing wells, yielding approximately 225 miner's inches of water, and, in 1903, only 134 pumping plants, most of them small, whose combined output during the pumping season certainly does not exceed 80 second-feet, equivalent to perhaps 15 or 20 second-feet continuous flow. This water is used for the towns and for somewhat less than 4,000 acres of irrigated lands.

In the Redondo quadrangle there are at present (1904) only 12 flowing wells, distributed over about 3.5 square miles, and about 200 pumping plants whose combined yield is probably 20 or 25 second-feet continuous flow. Three thousand two hundred and eighty acres are irrigated by sewage and about 8,250 acres from wells; this in a total irrigable area of perhaps 100 square miles.

In the two quadrangles more than $750,000 are invested in wells and pumps. The total area irrigated is 15,760 acres, the total amount of developed underground waters is between 40 and 50 second-feet, the original area of artesian lands is 28.4 square miles, the present (1904) artesian area is 8.7 square miles, and the total lowland area, much of which is not cultivated, is about 250 square miles. A part of the city of Los Angeles covers more than 22 square miles of this area, and the growing towns of Santa Monica, Ocean Park, Hollywood, Inglewood, Redondo, etc., occupy many more miles of it.

Although the quantity of water developed and the acreage irrigated by it are thus seen to be moderate, the local water supply is not controlled entirely by developments within the district considered, but is affected more or less by developments and diversions in adjacent regions. The shrinkage in that part of the coastal plain artesian basin which is included in the Redondo and Santa Monica

quadrangles, for instance, in so far as it is not due to drought, is probably due more to the complete diversion of Los Angeles River waters and to developments in the artesian basin farther east than to direct attacks on the ground waters in the areas in question.

The total number of flowing wells in the entire coastal plain artesian basin in 1904 was 2,500, and their yield is estimated at not less than 300 second-feet. The effect of this great drain in conjunction with the past decade of dry years has been to reduce the artesian area from about 290 to 190 square miles, the shrinkage taking place principally along the northern and northeastern borders of the basin, which first show the effects of a decrease in supply, for the same reason that water withdraws faster from the shallow upper end of a draining reservoir than from the lower deeper end. Hence in the Santa Monica and Redondo quadrangles the original area of 23 square miles is now reduced to 3.5 square miles.

The small Ballona basin, in which there are but four or five flowing wells, has not had serious drafts made upon it. Its situation, and the drainage tributary to it, should make it fairly resistant to reasonable drafts. The flowing wells about Colegrove are in deep-lying sandstones of Tertiary age and their life is difficult to estimate. The quality of these waters is not such as to invite their further exploitation so long as purer waters are obtainable.

With continued reasonable use of the underground waters of this area, then, it may be concluded that although the remnant of the coastal plain artesian basin included in it will probably disappear, because this basin is especially sensitive to distant diversions and developments, the ground waters generally will not suffer a serious permanent shrinkage.

## DESCRIPTION OF MAPS AND TABLES.

The greater portion of the data concerning the wells in the Santa Monica and Redondo quadrangles has been assembled, as in the other reports on the coastal plain, in a set of tables (pp. 22–103), in which the character of each well, its depth, the depth of water in it, the proportion of dissolved salts in the water, the cost of well and machinery, the name and address of the owner, the location of the well, etc., are given. In these tables each well is designated by a number, and on the maps the number appears with each well symbol, so that when the wells in any locality are of interest to an engineer or rancher, by reference to the tables he can readily ascertain their character.

The artesian basins have been outlined and appropriately tinted (Pls. V and VI), the areas in which water now flows being distinguished from those in which it has ceased to flow by a difference in shading. Outside of the artesian areas the elevations of the water surface are indicated by hydrographic contours wherever there are sufficient data on which to base them.

Northeast of the Dominguez ridge the water plane is very regular and its position is readily determined. Southwest of this ridge it is much lower and over much of the area is quite irregular. In the Santa Monica quadrangle the irregularity is accounted for by the irregular deposition of the alluvium which makes the bench land south of the Santa Monica Mountains. (Pl. III, *B*). Between Ballona Creek and San Pedro Hill the irregularity is not so marked, probably because the sands and gravels which are water bearing there are coastal plain sediments and sand-dune material. The ridge which separates these two areas is one over which water levels are exceedingly erratic. There can be little question that it represents an anticline in the earlier coastal plain gravels, sands, and clays, and the irregularity in the attitude of the water-bearing strata is the cause of the irregularity in the waters themselves.

In those places where, because of these erratic water levels, or for other reasons, sufficient data have not been collected to serve as a basis for hydrographic contours, such facts as we have on water levels are indicated by figures. None of the water levels are more than approximately accurate, since none are instrumentally determined. The estimate of the elevation of a well head is based upon surface elevations, as indicated by the contours of the topographic sheet. Careful measurements were made in each instance from the well head to the water level in the well. The hydrographic contours thus are based upon and exhibit approximately the same degree of accuracy as the topographic contours. They should, therefore, be consistent with the latter throughout, and a comparison of the two should give approximately the depth of water at any point.

It is to be remembered, however, that in the neighborhood of pumping plants, especially in the western half of the coastal plain below the Dominguez ridge, where the water supply is not generally so large as above the ridge, rapid variations of as much as 10 feet take place in the water level with the starting and stopping of pumps. The contours are intended to represent an average condition at the time when the data were gathered.

The lands under irrigation during the winter of 1903–4 are shown by color on each of the sheets. (Pls. VII and VIII.) In the Santa Monica quadrangle 360 acres are irrigated by sewage, and about 3,880 acres by stream and well water. In the Redondo quadrangle 3,280 acres are irrigated by sewage, and about 8,240 acres by pumped and flowing waters; the total irrigated area in the two quadrangles is about 15,760 acres, or 24.5 square miles in a total of more than 175 square miles irrigable, if water were available.

There is a large acreage of dry land under successful cultivation, perhaps more than is under irrigation, so that the unirrigated lands are not by any means all waste. In addition, the growing towns and

cities occupy constantly expanding areas. Los Angeles alone now covers about 20.5 square miles in the Santa Monica quadrangle.

The amounts of salts dissolved in the well waters were determined approximately by means of the electrolytic bridge, the conductivity of the water increasing with the increase in alkalies. The results of these tests are given under appropriate headings in the tables. They have also been assembled in a purity map, in which waters are classified in three divisions. In one division are included those waters

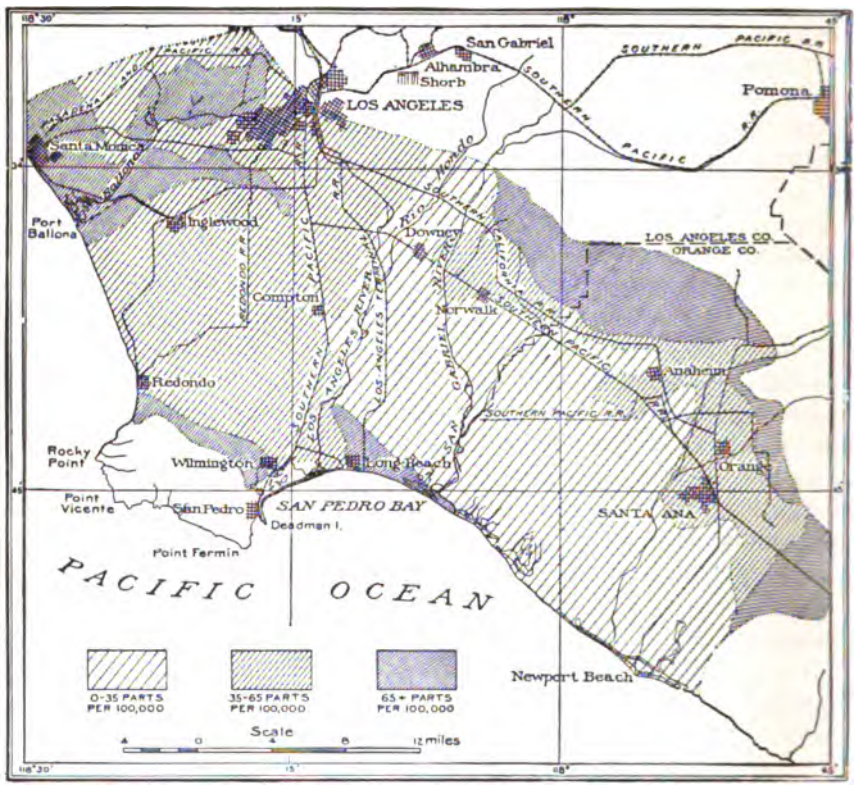


FIG. 1.—Map showing approximate amounts of dissolved solids in underground waters of the coastal plain region of southern California.

with less than 35 parts of dissolved matter in 100,000; in another are waters with from 35 to 65 parts of dissolved solids; and in the third are all waters containing more than 65 parts.

In the western section only waters of the last two classes occur, and the general distribution of the purity zones indicates a sluggish underground circulation as compared with those other parts of the coastal plain through which the greater part of the subsurface waters supplied by the Los Angeles, the San Gabriel, and the Santa Ana rivers passes. This inference follows directly from the fact that the purer waters are not sharply aligned in a definite relation to surface

streams as a source of supply, as is the case farther east. It is probable that the relatively slow movement of the underground waters in the western section, due to limited supply there, permits them to dissolve more of the soluble material from the sands and gravels through which they pass, and thus accounts for the greater proportion of salts which these western coastal plain waters contain. Yet a zone of relatively pure water extends from the Los Angeles River channel to the head of Ballona Creek and down the Ballona Valley to the Palms, below which it is cut off by the salt marshes of the coast. This may be supposed to be a direction of relatively free percolation.

To be strictly reliable as a guide only wells of considerable depth should be considered in the construction of purity maps, as shallow wells are so readily contaminated by the surface accumulation of alkalies. In the maps prepared for this report the records obtained from wells less than 25 feet deep have been disregarded, but even with this precaution the purity zones are no doubt somewhat influenced by surface conditions.

## ACKNOWLEDGMENTS.

The greater part of the field work in the Redondo quadrangle, including the collection of well data and the mapping of irrigated lands, was done by Messrs. L. B. Brainard and A. P. McCarton, while Mr. Brainard covered the Santa Monica area, with the exception of a little late revision carried out by Mr. W. N. White.

Messrs. A. J. Fisk, jr., and W. N. White have been of much assistance in the office in the reduction of the material to form for publication. Owners of wells and plants and irrigating companies have responded readily to requests for records and information, and to them acknowledgments are due.

To Mr. Homer Hamlin, engineer of the reclamation service, who inaugurated the work whose results are published here, the writer is indebted for much helpful counsel, as well as for active supervision of much of the earlier field work.

## WELL DATA.

*Wells in Santa Monica quadrangle.*

[* Cost of well and equipment combined. + Tank included, in column "Cost of machinery." † Yield estimated, or statement of owner taken. ? Doubtful.]

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Peter Taylor | Los Angeles city | L-16 | 1898 | | 165 | 130? | 50 | 63 | Wind | | $350.00 | Domestic | |
| 2 | Wm. Wibking | do | K-16, 17 | | Bored, 8-inch | 163 | 128 | | 65 | do | | | do | |
| 3 | H. C. Turner | do | K-16 | | Bored, 12-inch | 152 | 136 | | | Compressed air | | | Irrigation | |
| 4 | do | do | K-16 | | Bored, 10-inch | 152 | 136 | | | do | | | do | |
| 5 | Mr. C. Jensen | do | K-17 | | Bored, 8-inch | 150 | 131 | 47 | 53 | Wind | | | Domestic | |
| 6 | J. C. Garnett | do | L-17 | 1882 | Bored, 7-inch | 172 | 136 | 107 | 54 | do | $178.00 | 500.00 | do | |
| 7 | James Larquier | do | L-17 | | Bored, 8-inch | 170 | 95? | 175 | 44 | do | | | do | |
| 8 | W. J. Buckingham | do | L-17 | 1902 | Bored, 7-inch | 169 | 132 | 60 | 57 | do | | 250.00 | do | |
| 9 | L. Schlegel | Sec. 12, T. 2 S., R. 14 W. | L-17 | | Bored, 10-inch | 169 | 136 | 80 | | Gas | 480.00 | 1,160.00 | Irrigation | † 110 |
| 10 | do | do | L-17 | 1901 | do | 169 | 136 | 80 | 62 | do | | | | |
| 11 | do | do | L-17 | 1894 | Bored, 8-inch | 165 | 129 | 54 | 65 | Wind | 62.10 | 100.00 | Domestic; irrigation. | |
| 12 | McGue Bros | do | L-17 | 1901 | Bored, 8½-inch | 150 | 127 | 425 | 49 | Gas | 1,500.00 | 2,000.00 | Irrigation | 166 |
| 13 | do | do | L-17 | | Bored, 7-inch | 157 | 126 | 46 | 52 | Wind | | | Domestic | |
| 14 | Yost Lohsenger | do | L-17 | 1902 | do | 152 | 126 | 54 | 67 | Hand | 59.40 | | Domestic; stock | |
| 15 | L. Conneally estate | do | L-17 | 1902 | do | 151 | 126 | | 67 | Wind | | 350.00 | Domestic | |
| 16 | John W. Downs | Los Angeles city | L-17 | 1902 | do | 157 | 130 | 58 | 62 | do | 72.00 | | do | |
| 17 | W. H. Dinsmore | do | L-17 | 1901 | do | 161 | 130 | 50 | | do | 50.00 | 35.00 | do | |
| 18 | Peter Shutt | do | L-17 | 1888 | Bored, 6-inch | 163 | 128 | 70 | 65 | do | 70.00 | 100.00 | do | |
| 19 | James Crosby | do | L-17 | 1887 | Bored 8-inch | 164 | 128 | 180 | 61 | do | 207.00 | 400.00 | Domestic; irrigation. | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | Mrs. Geo. Lynch | do | K-17 | 1902 | Bored, 6-inch | 160 | 130 | 32 | 61 | do | 25.00 | 50.00 | do | |
| 21 | Mrs. A. G. Gardner | do | K-17 | 1880 | Bored, 7-inch | 153 | 133 | 39 | 68 | do | | | Domestic | |
| 22 | Mrs. E. M. Young | Sec. 12, T. 2 S., R. 14 W. | K-17 | 1897 | Bored, 8-inch | 146 | 136? | 40? | 69 | Hand | 40.00 | 25.00 | do | |
| 23 | Mr. Bosbyshell | Sec. 13, T. 2 S., R. 14 W. | K-17 | | Bored, 7-inch | 141 | 128 | 41 | 61 | Wind | | | Domestic; roads | |
| 25 | Wm. Dryden | Sec 11, T. 2 S., R. 14 W. | K-17 | 1880? | do | 136 | 128 | 45 | 66 | do | 50.00 | | Domestic | |
| 26 | Paggi Bros | do | K-17 | 1897 | do | 130 | 126 | 36 | 66 | do | 40.00 | | Domestic; stock | |
| 27 | E. J. Baldwin | Paso De La Tijera | I-17 | 1896 | do | 135 | 134 | 96 | 41 | do | 100.00 | 200.00 | Stock; domestic | |
| 28 | do | do | I-17 | 1878 | do | 195 | Dry. | 60 | | | | | | |
| 29 | do | do | J-17 | 1900 | do | 117 | 116 | 50 | 55 | Wind | 150.00 | | Stock | |
| 30 | R. Serrael | Los Angeles city | K-16 | 1900 | Dug, 7 by 7 foot | 155 | 131 | 27 | 44 | do | 150.00 | 150.00 | Domestic | |
| 31 | West Side Water Co | do | K-16 | 1903 | Bored, 12-inch | 151 | 132 | 650 | | | | | Not installed | |
| 32 | J. P. Riviere | do | K-16 | | Dug, 4 by 4 foot | 147 | 108 | 40 | 65 | Wind | | 60.00 | Domestic | |
| 33 | Silvan Barges | do | K-16 | 1885 | Bored, 7-inch | 139 | 132 | 200+ | 50 | Hand | 700.00 | | Stock | |
| 34 | Earl R. Osborn | Sec. 2, T. 2 S., R. 14 W. | J-16 | 1902 | Bored, 10-inch | 140 | 125 | 256 | | Gas | 700.00 | 1,300.00 | Irrigation | †150 |
| 35 | do | do | J-16 | 1902 | do | 140 | 125 | 50 | | do | | | do | |
| 36 | do | do | J-16 | 1902 | do | 140 | 125 | 58 | | do | | | do | |
| 37 | Artesian Water Co | Sec. 3, T. 2 S., R. 14 W. | J-16 | 1900 | Bored, 12-inch | 131 | 125 | 347 | | | | | Not used | |
| 38 | Earl R. Osborn | Sec. 2, T. 2 S., R. 14 W. | J-16 | 1897 | Bored, 7-inch | 141 | 126 | 142 | 53 | Wind | 175.00 | 125.00 | Domestic | |
| 39 | Artesian Water Co | Sec 3, T. 2 S., R. 14 W. | J-16 | | Dug, 4 by 4 foot | 141 | 126 | 30 | 47 | do | | 100.00 | do | |
| 40 | F. Benkert | Los Angeles city | K-15 | 1889 | Bored, 8-inch | 205 | 152 | 100 | 46 | do | | | do | |
| 41 | Mrs. Childs | Sec. 2, T. 2 S., R. 14 W. | K-15 | | | 184 | 146 | 345 | 46 | Gas | | | Domestic; irrigation. | |
| 42 | J. L. Starr | do | K-16 | 1901 | Bored | 162 | 140 | 100 | 48 | do | 100.00 | | Stock; domestic | |
| 43 | Artesian Water Co | do | K-16 | | Bored, 6-inch | 142 | 125 | 130 | | Wind | | | Not used | |
| 44 | Wm. Reid | Sec. 3, T. 2 S., R. 14 W. | J-16 | 1897 | Dug, 4 by 4 foot | 126 | 119 | 13 | 77 | Hand | 150.00 | | Domestic | |
| 45 | Artesian Water Co | do | J-16 | | Bored, 12-inch | 137 | 125 | 100 | | Wind | | | Irrigation | |
| 46 | do | Las Cienegas | J-16 | | do | 140 | 136 | | 52 | do | | | Domestic; stock | |
| 47 | do | do | I-16 | | do | 116 | 116 | 307 | 59 | Artesian | | | Irrigation | |
| 48 | do | do | I-16 | 1902 | do | 116 | 116 | 801 | 40 | do | | | do | 50 |
| 49 | do | do | J-15 | 1896 | Bored, 7-inch | 145 | 135 | 233 | 50 | Wind | | | Domestic | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | Artesian Water Co | Las Cienegas | I-16 | | Bored, 12-inch | 127 | 121 | | 56 | Wind | | | Domestic; irrigation. | |
| 51 | Mr. D. Avila | do | I-15 | 1902 | Dug, 4 by 4 foot, 45 feet; bored, 7-inch, 135 feet. | 165 | 125 | 180 | 72 | do | $180.00 | $75.00 | Domestic | |
| 52 | F. Rimpan | do | I-16 | 1903 | Bored, 12-inch | 120 | 119 | 297 | 45 | Artesian | 500.00 | | Irrigation | |
| 53 | A. Kravchyk | do | K-15 | 1894 | Bored, 8¼-inch | 220 | 150 | 280 | 46 | Gas | *1,000.00 | | Irrigation; domestic. | |
| 54 | Thos. Higgins | Los Angeles city | M-16 | 1885 | Bored, 8-inch | 200 | 136 | 64 | | Wind | | | Domestic | |
| 55 | Wm. W. Carter | do | M-16 | 1888 | do | 189 | 147? | 64 | 63 | do | | 100.00 | do | |
| 56 | Mrs. Simonsen | do | M-17 | | Bored, 7-inch | 187 | 134 | 63 | 60 | do | | 100.00 | | |
| 57 | Chas. Mettler | do | M-17 | 1902 | Bored, 8-inch | 190 | 133 | 82 | 58 | do | | 150.00 | Domestic | |
| 58 | Mrs. Messbaum | do | M-17 | 1902 | do | 192 | 134 | 107 | 53 | do | 122.00 | 100.00 | do | |
| 59 | H. Boettcher | do | N-16, 17 | | do | 205 | 130 | 75 | | do | | 100.00 | do | |
| 60 | Robert Matheson | do | N-16 | 1893 | Bored, 7-inch | 211 | 134 | 83 | 40 | do | | 100.00 | do | |
| 61 | L. E. Shepherd | do | N-16 | 1898 | do | 209 | 136 | 107 | 57 | do | | | Domestic; irrigation. | |
| 62 | Wm. B. Brown | do | N-17 | 1889 | do | 201 | 132 | 85 | 54 | Hand | | | Domestic | |
| 63 | Mr. Birchfield | do | N-17 | | Bored, 6-inch | 193 | 133 | 110 | 40 | Wind | | 100.00 | do | |
| 64 | Joseph Sweetapple | do | N-17 | | Bored, 7-inch | 193 | 132 | 62 | 58 | do | 150.00 | | do | |
| 65 | Dr. McCullough | do | N-17 | 1900 | Bored, 10-inch | 187 | 134 | 150 | 61 | Gas | | 1,800.00 | Irrigation | |
| 66 | do | do | N-17 | | Bored, 7-inch | 184 | 132 | 60 | 66 | Wind | 100.00 | | Domestic | |
| 67 | B. F. Buller | do | N-17 | | do | 177 | 128 | 80 | 60 | do | | 100.00 | do | |
| 68 | G. W. Kendall | do | N-17 | 1882 | do | 181 | 126 | 60 | 68 | do | | 100.00 | do | |
| 69 | Mrs. S. Lamphier | do | M-17 | | do | 186 | 135 | 55 | 58 | Hand | | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | Strong & Dickinson, agents. | do | M 17 | | do | 184 | 139 | 194 | 53 | Wind | | | do | | |
| 71 | Mrs. A. L. Acker | do | M-17 | 1900 | do | 180 | 136 | 51 | 71 | do | | | Domestic; irrigation. | | |
| 72 | N. C. Oswald | do | M-17 | 1902 | Bored, 10-inch | 175 | 133 | 230 | 61 | Gas | 310.50 | | Irrigation | | |
| 73 | do | do | M-17 | 1902 | do | 175 | 133 | 72 | 61 | do | | | do | | |
| 74 | Mr. McNary | do | M-17 | | Bored, 7-inch | 180 | 132 | 64 | 61 | Wind | | | Domestic | | |
| 75 | Chas. Rohr | do | N-17 | 1899 | do | 182 | 128 | 66 | 69 | do | 200.00 | | do | | |
| 76 | Mrs. M. A. Burns | do | N-17 | | do | 186 | | 65 | 57 | do | | | do | | |
| 77 | John Redmond | do | N-17 | 1895 | do | 186 | 128 | 64 | 41 | do | 75.00 | 100.00 | do | | |
| 78 | O. F. Gehre | do | N-17 | | do | 200 | 135 | 125 | 57 | do | | 100.00 | Domestic; irrigation. | | |
| 79 | Daniel Tachet | do | N-17 | 1900 | Dug, 4 by 4 foot | 201 | Dry. | 56 | | do | 300.00 | 100.00 | | | |
| 80 | M. F. Moss | do | N-17 | | Bored, 7-inch | 200 | 133 | 110 | 54 | do | | 100.00 | Domestic | | |
| 81 | J. R. Gager | do | N-17 | 1901 | Bored, 10-inch | 201 | 141 | 171 | 58 | Gas | *2,000.00 | | Domestic; irrigation. | | |
| 82 | do | do | N-17 | 1900 | do | 201 | 141 | 70 | | Wind | | | Not used | | |
| 83 | D. E. Muttersbaugh | do | N-17 | 1897 | Bored, 7-inch | 205 | 135 | 114 | 56 | do | 250.00 | 100.00 | Domestic | | |
| 84 | H. C. Simmons | do | M-17 | 1896 | Bored, 6-inch | 204 | 136 | 101 | 61 | do | | | do | | |
| 85 | M. P. Lucas | do | N-17 | 1895 | Bored | 208 | 134 | 79 | 57 | do | | | do | | |
| 86 | W. H. Merrill | do | N-17 | 1895 | Bored, 7-inch | 208 | 134 | 84 | | do | | 100.00 | do | | |
| 87 | Geo. Getchell | do | N-17 | 1883 | do | 204 | 138 | 84 | 57 | do | | | do | | |
| 88 | J. R. Dorsey | do | N-17 | 1901 | Bored, 12-inch | 204 | 138 | 211 | 52 | Gas | | | Irrigation | | 120 |
| 89 | L. E. Shepherd | do | N-17 | | Dug | 204 | Dry. | 55 | | | | | | | |
| 90 | James Oakley | do | N-17 | 1883 | Bored, 7-inch | 202 | 135 | 68 | | Wind | 100.00 | 200.00 | Not used | | |
| 91 | J. Pauly | do | N-17 | | Bored, 8-inch | 201 | 135 | 76 | 65 | do | 100.00 | 75.00 | Domestic | | |
| 92 | Guy Owen | do | N-17 | | do | 204 | Dry. | 68 | | | | | | | |
| 93 | G. J. Reinacker | do | N-17 | 1901 | Bored, 6-inch | 198 | 136 | 135 | 56 | Wind | 200.00 | 120.00 | Domestic; irrigation. | | |
| 94 | Sam Park | do | N-17 | 1901 | Bored, 7-inch | 199 | 136 | 130 | 58 | do | | | Domestic | | |
| 95 | H. Brewer | do | N-17 | 1899 | Bored, 6-inch | 198 | 146? | 107 | 57 | do | | | do | | |
| 96 | T. A. Harris | do | N-17 | 1900 | do | 196 | 136 | 61 | | do | 90.00 | 100.00 | Not used | | |
| 97 | Dr. M. S. Ertle | do | N-17 | 1892 | Bored, 7-inch | 197 | 134 | 63 | | | | | do | | |
| 98 | Mr. Sherwood | do | N-17 | | Bored, 6-inch | 193 | | | 65 | Wind | | 100.00 | Domestic | | |
| 99 | J. C. Scott | do | N-17 | 1886 | Bored, 7-inch | 193 | 136 | 70 | 57 | do | | | do | | |
| 100 | Dr. W. B. Wood | do | N-17 | | do | 200 | 142 | 81 | 59 | do | | 100.00 | do | | |
| 101 | A L. Whitney | do | N-17 | 1883 | do | 201 | 143 | 64 | | | | | Not used | | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 102 | E. M. Milsap | Los Angeles city | N-17 | 1898 | Bored, 7-inch | 202 | 142 | 65 | | | | | Not used | |
| 103 | J. B. Okey | do | N-17 | 1895 | do | 190 | 130 | 64 | 61 | Wind | | | Domestic | |
| 104 | M. E. Donavan | do | N-17 | 1901 | do | 188 | 138? | 74 | 58 | do | $100.00 | $100.00 | do | |
| 105 | W. E. Godsey | do | N-17 | 1902 | do | 195 | 139 | 74 | 56 | do | | | do | |
| 106 | F. G. Gotts | do | M-17 | 1893 | do | 193 | 137 | 70 | 39 | Hand | | | do | |
| 107 | W. C. Banks | do | M-17 | 1896 | Bored, 8-inch | 194 | 137 | 66 | 64 | Wind | | | do | |
| 108 | P. J. Hummel | do | M-17 | 1885 | Bored | 184 | 133 | 60 | 59 | do | | | do | |
| 109 | Geo. Worth | do | M-17 | | Bored, 6-inch | 183 | 130 | 67 | 60 | do | | | Domestic; stock | |
| 110 | A. H. Brocamp | do | M-17 | 1899 | Bored, 9-inch | 180 | 132 | 190 | | Gas | 380.00 | 2,500.00 | Irrigation | |
| 111 | N. Bartol | do | M-17 | 1884 | Bored | 180 | 120 | 90 | 63 | Wind | | | Domestic | |
| 112 | Fred Espe | do | M-17 | 1900 | Bored, 9-inch | 174 | 134 | 64 | 73 | Gas | 200.00 | 825.00 | Irrigation | |
| 113 | Mrs. Laura Carter | do | M-17 | 1898 | Bored, 8-inch | 173 | 132 | 49 | 73 | Wind | | | Domestic | |
| 114 | John Thill | do | M-17 | 1895 | Bored, 7-inch | 175 | 135 | 49 | 61 | do | 100.00 | | do | |
| 115 | T. Schroeder | do | M-17 | 1900 | do | 175 | 135 | 52 | 64 | do | | 100.00 | do | |
| 116 | Irwin McGinnis | do | M-17 | 1900 | do | 177 | 134 | 61 | 67 | do | 75.00 | 75.00 | do | |
| 117 | L. A. Postmaster | do | M-17 | | do | 181 | 135 | 50 | 63 | Hand | | | do | |
| 118 | Geo. Zobelein | do | M-17 | 1903 | Bored, 8-inch | 186 | 131 | 150 | 62 | Gas | | | Domestic; irrigation. | |
| 119 | do | do | M-17 | 1901 | Bored, 10-inch | 188 | 133 | 190 | 57 | Electric motor | | | Irrigation | |
| 120 | Agricultural Park Dairy. | do | M-17 | | Bored, 6-inch | 185 | 126 | 73 | 62 | Wind | | | Domestic | |
| 121 | W. T. Austermell | Sec. 7, T. 2 S., R. 13 W. | M-17 | 1895 | do | 176 | 135 | 60 | 58 | do | | | Domestic; stock | |
| 122 | Mr. Thorpe | Los Angeles city | M-17 | | Bored, 8-inch | 175 | 129 | 68 | 65 | do | | | do | |
| 123 | F. H. Redpath | do | M-17 | 1903 | do | 175 | 129 | 53 | 63 | do | | 75.00 | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 124 | P. W. Gertz | do | M-17 | 1891 | Bored, 7-inch | 174 | 135 | 48 | 86 | do | 50.00 | 75.00 | do | |
| 125 | J. W. Sommerville | do | M-17 | 1895 | do | 165 | 150? | 45 | 69 | Wind, gas | | | Domestic; irrigation. | |
| 126 | do | Sec. 7, T. 2 S., R. 14 W. | L-17 | 1903 | do | 162 | 127 | 98 | 61 | Hand | 110.00 | | Stock | |
| 127 | Dr. Pratt | Los Angeles city | M-16 | | | 190 | | | | Wind | | | Not used | |
| 129 | C. T. Stewart | do | M-16 | 1895 | Bored, 7-inch | 188 | 133 | 66 | 64 | do | | 125.00 | Domestic | |
| 130 | Mrs. E. E. Brown | do | L-16 | 1896 | Bored, 6-inch | 182 | 134 | | 56 | do | | 100.00 | do | |
| 131 | Mrs. L. S. Elliott | do | L-16 | 1894 | Bored, 7-inch | 182 | 133 | 96 | 57 | do | | | do | |
| 132 | Mrs. H. P. Andrews | do | L-16 | 1881 | do | 177 | 136 | 82 | 63 | do | | 100.00 | do | |
| 133 | Henry Knauff | do | M-16 | 1888 | Bored, 6-inch | 189 | 146? | 100 | 92 | do | 135.00 | 100.00 | do | |
| 134 | Thos. Bones | do | L-16 | 1894 | Bored, 7-inch | 190 | 146 | 72 | 69 | do | 75.00 | 325.00 | do | |
| 135 | Dr. W. H. Palmer | do | L-16 | 1894 | do | 185 | Dry. | 40 | | do | 60.00 | 500.00 | Not used | |
| 136 | Thos. Lloyd, agent | do | L-16 | | Bored, 8-inch | 185 | 138 | 75 | 64 | do | | | Domestic | |
| 137 | Redondo Rwy. Co | do | M-16 | 1875 | Bored, 6-inch | 196 | 135 | 113 | 61 | do | | | Engines | |
| 138 | Mrs. John Rey | do | L-16 | | Bored, 8-inch | 184 | 135 | 61 | 58 | do | | | Domestic | |
| 139 | Agricultural Park | do | L-16, 17 | | do | 177 | | | | Gas | | | Roads | |
| 140 | G. W. Guinn | do | L-16 | 1889 | Bored, 7-inch | 177 | 136 | 112 | 61 | Wind | | | Domestic | |
| 141 | A. Armbruster | Sec. 7, T. 2 S., R. 13 W. | L-17 | 1895 | Bored, 8-inch | 166 | 125 | 50 | 63 | do | | 100.00 | do | |
| 142 | Dr. F. J. Kruel | do | L-17 | | Bored, 7-inch | 160 | 126 | 57 | 65 | do | | | Domestic; stock | |
| 143 | Mr. Butler | do | L-17 | | do | 160 | 125 | 52 | 68 | do | | | Domestic | |
| 144 | H. A. Goldbach | Los Angeles city | K-15 | 1893 | Bored, 8-inch | 213 | 141 | 270 | 54 | do | | | do | |
| 145 | Mr. Crippen | do | K-15 | | Bored, 7-inch | 209 | 140 | 89 | 54 | do | | | do | |
| 146 | F. W. Marshall | do | K-15 | 1901 | Bored, 10-inch | 198 | 130 | 235 | 129 | Gas | 400.00 | 1,500.00 | do | |
| 147 | Otto Wilhelm | Las Cienegas | J, K-15 | 1902 | Bored, 8-inch | 210 | 140 | 159 | 81 | Wind | 300.00 | 100.00 | | |
| 148 | Mr. Nelson | do | J-15 | 1898 | Bored, 7-inch | 220 | 145 | 156 | 54 | do | | 100.00 | Domestic | |
| 149 | Mrs. F. W. Sonnenburg. | do | J-15 | 1896 | Bored, 6-inch | 195 | 126 | 99 | 125 | do | | | do | |
| 150 | G. R. Reed | do | J-15 | 1900 | Bored, 18-inch, 50 feet; bored, 12-inch, 32 feet. | 180 | 121 | 82 | 74 | do | 25.00 | 70.00 | do | |
| 151 | do | do | J-15 | 1883 | Bored, 7-inch | 180 | 121 | 90 | 74 | do | 125.00 | 400.00 | do | |
| 152 | Otto Wilhelm | do | J-15 | 1901 | Bored, 10-inch | 195? | 130? | 200 | 76 | do | | 100.00 | Domestic; stock | |
| 153 | Max Byer | do | J-15 | 1893 | Bored | 188 | 120 | 98 | 145 | do | | | Domestic | |
| 154 | Joseph Burkhart | do | J-15 | | Bored, 7-inch | 174 | 123 | 82 | | | | | Not used | |
| 155 | Dr. Nadeau | do | J-15 | 1887 | Bored, 8-inch? | 180 | 64 | 174 | 72 | Wind | | | Domestic | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 156 | Los Angeles County | Las Cienegas | J-15 | 1899 | Bored, 7-inch | 171 | 120 | 96 | 84 | Wind | | | Stock; roads | |
| 157 | Nevada and California Real Estate Co. | do | J-15 | | Bored, 8-inch | 161 | 121 | 62 | 67 | do | | | Domestic | |
| 158 | O. H. Burbridge | Los Angeles city | K-15 | | Bored, 7-inch | 220 | 136 | 88 | | Not used | | | Not used | |
| 159 | M. L. Beardsley | do | K-15 | 1899 | do | 220 | 136 | 235 | 47 | Wind | $400.00 | $100.00 | Domestic | |
| 160 | Ferdinand Holm | do | K-15 | 1881 | Bored, 8-inch | 210 | 128 | 125 | 47 | do | | | do | |
| 161 | C. F. Stuart | do | K-15 | 1884 | Bored, 7-inch | 205 | 137 | 87 | 54 | do | 90.00 | 200.00 | do | |
| 162 | Mrs. F. Gason | do | K-15 | 1892 | Bored, 9-inch | 200 | 137 | 230 | 54 | do | 540.00 | 560.00 | do | |
| 163 | Mrs. M. Mitchell | do | K-15 | 1887 | Bored, 7-inch | 201 | 137 | 100 | 70 | do | | | do | |
| 164 | A. C. Eschrich | do | K-15 | | do | 200 | 137 | 81 | 125 | do | | | do | |
| 165 | Miss Kate Bagnall | do | L-15 | 1888 | Bored | 206 | 137 | 79 | 101 | do | | | do | |
| 166 | Mr. Orr | do | L-14, 15 | | Bored, 7-inch | 200 | 137 | 75 | 101 | do | | | do | |
| 167 | John Bruckner | do | L-15 | 1888 | do | 212 | 137 | 90 | 56 | do | | | do | |
| 169 | Henry C. Jensen | do | K-15 | 1887 | do | 200 | 143 | 82 | 56 | do | | | do | |
| 170 | do | do | K-15 | | Dug, 4 by 4 foot, 66 feet; bored, 7-inch, 234 feet. | 200 | | 300 | | | | | Not used | |
| 171 | Leo Jouromsky | do | K-16 | 1900 | Bored, 7-inch | 163 | 130 | 100 | 39 | Wind, gas | 150.00 | | Domestic; irrigation. | |
| 172 | F. A. Ripley | do | K-16 | 1900 | do | 164 | 130 | 90 | 42 | Wind | 100.00 | 100.00 | Domestic | |
| 173 | A. B. Tomlinsom | do | K-15 | | do | 220 | 136 | 149 | | Electric motor | | 350.00 | do | |
| 174 | P. Pearson | do | L-15 | 1892 | do | 185 | 136 | 67 | 54 | Wind | 100.00 | 100.00 | do | |
| 175 | J. W. Brown | do | L-15 | | do | 185 | 136 | 67 | 68 | do | | | do | |
| 176 | R. Radford | do | L-15 | | do | 190 | 136 | 65 | 43 | do | | | do | |
| 177 | A. Kosta | do | L-15 | 1895 | do | 190 | 135 | 83 | 39 | do | | 100.00 | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 178 | T. Widd | do | L-15 | 1890? | do | 192 | 132 | 75 | 44 | do | 100.00 | 100.00 | do | |
| 179 | A. J. Franklin | do | L-15 | 1886 | do | 189 | 137 | 104 | 54 | do | 125.00 | | do | |
| 180 | Mrs. F. Karpe | do | L-15 | 1883 | do | 185 | 137 | 63 | 50 | do | | | do | |
| 181 | Fred Fritz | do | L-16 | 1896 | do | 187 | 137 | 100 | 52 | do | 95.00 | 250.00 | do | |
| 182 | Harry Weiss | do | L-16 | 1900 | do | 182 | 137 | 225 | 56 | Wind, gas | 375.00 | 1,200.00 | Domestic; irrigation. | |
| 183 | Thos. W. Brown, sr | do | L-16 | 1898 | do | 182 | 134 | 100 | 47 | Wind | 125.00 | 100.00 | Domestic | |
| 184 | E. A. Hoffman | do | L-16 | 1892? | do | 177 | 139 | 75 | 56 | do | | | do | |
| 185 | Herbert J. Warner | do | L-16 | 1887 | do | 182 | 134 | 80 | 52 | do | 200.00 | | do | |
| 186 | Tony Bright | do | L-16 | 1894 | do | 184 | 139 | 135 | 64 | do | 150.00 | [a]1,200.00 | do | |
| 187 | Mrs. C. M. Yale | do | L-16 | 1898 | do | 183 | 139 | 260 | 74 | do | 300.00 | 150.00 | do | |
| 188 | W. J. Bryant | do | L-16 | 1898 | do | 178 | 138 | 45 | 70 | do | | | do | |
| 189 | R. A. Wiley | do | L-16 | 1897 | do | 175 | 138 | 55 | | do | 75.00 | 100.00 | do | |
| 190 | Wm. Rudge | do | L-16 | 1897 | do | 169 | 134 | 51 | 58 | do | 56.00 | 65.00 | do | |
| 191 | J. W. Dodge | do | L-16 | 1897 | do | 168 | 138 | 74 | 63 | do | 78.00 | 70.00 | do | |
| 192 | Mrs. E. A. Northrop | do | L-16 | 1889 | do | 165 | 135 | 47 | 51 | do | 50.00 | 100.00 | do | |
| 193 | G. H. Paine | do | K-16 | 1897 | do | 164 | 135 | 79 | 58 | do | 100.00 | 100.00 | do | |
| 194 | W. M. March | do | K-16 | | do | 157 | 131 | 47 | 57 | do | | | do | |
| 195 | H. G. Spottswood | do | L-16 | 1897 | do | 175 | 139 | 64 | 59 | do | 70.00 | 75.00 | do | |
| 196 | J. E. Mahoney | do | L-16 | 1894 | do | 168 | 134 | 78 | 68 | do | 105.00 | | do | |
| 197 | G. W. Hood | do | K-16 | | do | 167 | 131 | 73 | 45 | do | | | do | |
| 198 | Mrs. Emelie Hertel | do | K-16 | 1897 | do | 157 | 130 | 60 | 41 | do | 60.00 | 75.00 | do | |
| 199 | C. W. Johnston | do | K-16 | 1901 | do | 157 | 131 | 48 | 53 | Hand | | | Not used | |
| 200 | Lee McConnell | do | K-16 | 1896 | Dug, 3½ by 3½ foot. | 150 | 130 | 21 | 81 | do | 25.00 | | Domestic | |
| 201 | A. E. Guinn | do | L-16 | 1895 | Bored, 7-inch | 172 | 130 | 65 | 57 | Wind | | | do | |
| 202 | Dr. Wylie | La Brea | J-11 | | do | 342 | 274 | 137 | 59 | do | | | do | |
| 203 | F. L. Dodge | do | J-11 | 1897 | do | 314 | 275 | 52 | 58 | do | | | do | |
| 204 | H. Kettle | do | J-11 | 1900 | Dug, 6 by 4 foot. | 297 | 270 | 37 | 54 | Gas | | | Domestic; irrigation. | |
| 205 | N. A. Watson | do | J-11 | 1895 | Bored, 7-inch | 313 | 274 | 50 | 56 | Wind | 50.00 | 200.00 | Domestic | |
| 206 | F. L. Dodge | do | J-11 | 1899 | Bored | 298 | 270 | 46 | 50 | do | 50.00 | 250.00 | do | |
| 207 | R. H. Jones | do | J-12 | 1892 | Bored, 7-inch | 334 | 279 | 160 | 65 | Gas | 230.00 | 450.00 | Domestic; irrigation. | |
| 209 | Mrs. Ida Henkle | do | J-12 | 1885 | Dug, 3 by 3 foot. | 280 | Dry. | 35 | | | | | | |

[a] Includes cost of tank house.

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 208 | Mrs. Ida Henkle | La Brea | J-12 | 1899 | Dug, 4 by 6 foot, 24 feet; bored, 9-inch, 16 feet. | 280 | 263 | 40 | 60 | Gas | $100.00 | $400.00 | Domestic | †7 |
| 210 | A. C. Haley | do | J-12 | 1899 | Bored, 7-inch | 272 | 250 | 25 | 56 | Wind | 35.00 | 50.00 | do | |
| 211 | Mrs. E. G. Eckhart | do | J-12 | | do | 279 | 229 | 53 | 53 | do | | | do | |
| 212 | Mr. C. Cole | do | J-11 | | do | 296 | 272 | 47 | 54 | do | | | do | |
| 213 | James Warren | Los Felis | L-11 | 1890 | do | 420 | 329 | 112 | 54 | do | | | Domestic; irrigation. | |
| 214 | do | do | L-11 | 1895 | do | 417 | 329 | 167 | 34 | Gas | | | Irrigation | |
| 215 | Martin Stoll | do | L-11 | 1902 | Bored | 422 | 329 | 126 | 26 | Wind | | | Domestic | |
| 216 | Mrs. S. Whitman | do | L-11 | 1895? | Dug, 3-foot diameter. | 401 | 330 | 72 | 24 | do | | | do | |
| 217 | Mrs. Anna Baumeister | do | L-11 | 1895 | do | 375 | 318 | 62 | 26 | Hand | | | do | |
| 218 | C. S. Billman | do | L-11 | 1903 | Bored, 6-inch | 370 | 315 | 81 | 38 | do | 61.00 | 27.00 | do | |
| 219 | L. H. Price | do | L-10 | 1889 | Dug, 6-foot diameter. | 480 | 468 | 22 | 31 | Gas | | | Domestic; irrigation. | |
| 220 | C. J. Griffith | do | L-10 | 1892 | Dug, 3-foot diameter. | 480 | 459 | 40 | 31 | Hand | | | Domestic | |
| 221 | Mrs. Mary Martin | do | L-10 | 1890 | Bored, 7-inch | 550 | 501 | 100 | 26 | Wind | 130.00 | 150.00 | do | |
| 222 | L. Salter | do | L-10 | 1899 | Dug, 4½-foot diameter. | 555 | 510 | 48 | 22 | Gas | 75.00 | 250.00 | Domestic; irrigation. | |
| 223 | W. H. Hoegee | do | L-10 | 1902 | Bored, 8-inch | 540 | | 370 | | do | | | do | |
| 224 | G. W. Price | do | L-10 | 1887 | Dug, 6 by 4 foot. | 500 | 468 | 40 | 41 | Wind | | 100.00 | Domestic | |
| 225 | Morgan Griffith | do | L-10 | 1901 | Bored, 7-inch | 500 | 450 | 125 | 19 | Gas | 125.00 | | Domestic; irrigation. | |
| 226 | C. F. Fosdick | do | L-10 | 1897 | | 500 | 453 | 72 | | Wind | 100.00 | 100.00 | do | |
| 227 | S. A. Leaverton | do | L-10 | | Bored, 7-inch | 510 | 482 | 80 | 26 | do | 100.00 | 75.00 | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 228 | .....do..... | .....do..... | L-10.... | ..... | Dug, 5-foot diameter. | 515 | 478 | 60 | 27 | .....do..... | 100.00 | 75.00 | Irrigation..... | ..... |
| 229 | .....do..... | .....do..... | L-10.... | 1902 | Bored, 12-inch.. | 510 | 488 | 254 | 28 | Gas..... | 472.00 | 500.00 | .....do..... | †5 |
| 230 | Wm. Gregory..... | .....do..... | L-10.... | ..... | Bored, 16-inch.. | 510 | 496 | 50 | 27 | Wind..... | ..... | 100.00 | .....do..... | ..... |
| 231 | Ambrose Gregory .... | .....do..... | L-10.... | 1883 | Bored, 7-inch... | 500 | 495 | 300 | 25 | Gas..... | 400.00 | 400.00 | .....do..... | ..... |
| 232 | T. Brotherton..... | .....do..... | L-10.... | 1883? | .....do..... | 500 | 493 | 325 | ..... | Tunnel..... | ..... | ..... | .....do..... | ..... |
| 233 | .....do..... | .....do..... | L-10.... | 1883? | .....do..... | 500 | 493 | 120? | ..... | .....do..... | ..... | ..... | .....do..... | ..... |
| 234 | Little & Warren..... | .....do..... | L-10.... | ..... | .....do..... | 490 | 485 | 50 | ..... | .....do..... | ..... | ..... | .....do..... | ..... |
| 235 | .....do..... | .....do..... | L-10.... | ..... | Bored, 12-inch.. | 490 | 485 | 50 | ..... | .....do..... | ..... | ..... | .....do..... | ..... |
| 236 | .....do..... | .....do..... | L-10.... | ..... | Bored, 7-inch... | 490 | 485 | ..... | ..... | .....do..... | ..... | ..... | .....do..... | ..... |
| 237 | .....do..... | .....do..... | L-10.... | ..... | .....do..... | 490 | 485 | ..... | ..... | ..... | ..... | ..... | .....do..... | ..... |
| 238 | .....do..... | .....do..... | L-10... | ..... | .....do..... | 490 | 485 | ..... | ..... | ..... | ..... | ..... | .....do..... | ..... |
| 239 | W. S. Sutton..... | .....do..... | L-10.... | 1901 | .....do..... | 490 | 485 | 90 | 25 | Gas..... | ..... | ..... | .....do..... | ..... |
| 240 | .....do..... | .....do..... | L-10.... | 1901 | Bored, 16-inch.. | 490 | 485 | 90 | 24 | .....do..... | ..... | ..... | .....do..... | ..... |
| 241 | .....do..... | .....do..... | L-10.... | 1896 | Bored, 7-inch... | 480 | 479 | 102 | ..... | Wind..... | 125.00 | 100.00 | Domestic..... | ..... |
| 242 | J. L. Siedzianoski.... | .....do..... | L-10.... | 1895? | .....do..... | 450 | 432 | 100 | 31 | .....do..... | ..... | ..... | .....do..... | ..... |
| 243 | District school..... | .....do..... | L-10.... | ..... | .....do..... | 520 | 478 | 67 | ..... | ..... | ..... | ..... | ..... | ..... |
| 244 | Mr. Griffith..... | .....do..... | L-10.... | 1902 | Bored, 12-inch.. | 480 | 437 | 94 | 28 | Hand..... | ..... | ..... | Domestic..... | ..... |
| 245 | W. E. Cummings..... | .....do..... | L-10.... | 1897 | Dug, 3 by 4½ foot | 480 | 451 | 41 | 34 | Gas, wind..... | ..... | ..... | Domestic; irrigation. | ..... |
| 247 | Homer Laughlin..... | .....do..... | K-10.... | 1901 | Bored, 12-inch.. | 485 | 465 | 400 | 48 | Wind..... | 2,000.00 | 100.00 | Irrigation..... | ..... |
| 248 | T. A. Fry..... | .....do..... | K-10.... | 1902 | Bored, 5½-inch .. | 490 | 468 | 60 | 53 | .....do..... | 75.00 | 100.00 | Domestic..... | ..... |
| 249 | Homer Laughlin..... | .....do..... | K-10.... | 1902 | Bored, 7⅝-inch .. | 470 | 461 | 60 | ..... | ..... | 75.00 | ..... | Not installed..... | ..... |
| 250 | E. L. Allen..... | .....do..... | K-10.... | 1893 | Bored, 7-inch... | 440 | 362 | 98 | ..... | Wind..... | ..... | ..... | Domestic..... | ..... |
| 251 | W. E. Cummings ..... | .....do..... | L-10.... | 1897 | .....do..... | 500 | 452 | 68 | 36 | ..... | ..... | ..... | Not used..... | ..... |
| 252 | E. L. Allen..... | .....do..... | K-10.... | 1901 | Bored, 10-inch.. | 440 | 283 | 200+ | ..... | ..... | ..... | ..... | .....do..... | ..... |
| 253 | Mr. Griffith..... | .....do..... | L-10.... | 1902 | Bored, 16-inch.. | 440 | 359 | 1,100 | ..... | ..... | ..... | ..... | .....do..... | ..... |
| 254 | .....do..... | .....do..... | L-10.... | 1897 | Bored, 6-inch... | 440 | 379 | 121 | 32 | Gas..... | ..... | ..... | Irrigation..... | ..... |
| 255 | .....do..... | .....do..... | L-10.... | ..... | Bored, 12-inch.. | 450 | 446 | 146 | 72 | ..... | ..... | ..... | Not used..... | ..... |
| 256 | Peter Tanner..... | .....do..... | L-10,11. | 1899 | Bored, 7-inch... | 430 | 370 | 225 | 72 | Gas..... | 350.00 | 600.00 | Domestic; irrigation. | ..... |
| 257 | Geo. H. Stoll..... | .....do..... | L-10,11. | ..... | .....do..... | 425 | 343 | 95 | 67 | Wind..... | ..... | ..... | .....do..... | ..... |
| 258 | S. Taylor..... | .....do..... | L-10.... | 1890 | .....do..... | 425 | 361 | 102 | 35 | .....do..... | ..... | ..... | .....do..... | ..... |
| 259 | J. M. Geib..... | .....do..... | L-10.... | 1898 | .....do..... | 434 | 342 | 126 | 30 | Gas..... | 200.00 | 200.00 | Irrigation..... | ..... |
| 260 | J. A. Lewis..... | .....do..... | L-10.... | 1901 | .....do..... | 445 | 408 | 76 | 36 | Wind..... | ..... | ..... | Domestic..... | ..... |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 261 | D. M. Little | Los Felis | L-10 | 1893? | Dug, 3-foot diameter. | 460 | 433 | 24 | 68 | Wind | | | Domestic; irrigation. | |
| 262 | Mrs. H. E. Newton | do | L-10 | 1883 | Bored, 7-inch | 440 | 364 | 120 | 32 | do | $125.00 | $200.00 | Domestic | |
| 263 | H. A. Bourne | do | L-11 | 1883 | Bored, 8-inch | 430 | 351 | 88 | 29 | do | | | do | |
| 264 | R. M. Tull | do | K, L-11 | 1895 | Bored, 7-inch | 384 | 304 | 197 | 43 | Gas | *1,000.00 | | Domestic; irrigation. | |
| 265 | E. A. Eaton | do | K-11 | 1890 | do | 390 | 313 | 162 | 44 | do | 200.00 | 250.00 | do | |
| 266 | Mrs. Caroline Lamb | do | K-11 | 1890 | do | 405 | 320 | 156 | 54 | Wind, gas | 200.00 | | do | |
| 267 | Mrs. E. B. Wakeman | do | K-11 | | do | 400 | 320 | 140 | | Gas | | | do | |
| 268 | Lewis Ferry | do | K-11 | 1895 | do | 386 | 306 | 287 | 48 | do | 500.00 | 600.00 | do | †6 |
| 269 | J. V. Dodds | do | K-11 | 1893 | do | 386 | 288 | 191 | 49 | Wind | 273.00 | 300.00 | Domestic | |
| 270 | J. H. Devol | do | K-11 | 1894 | do | 382 | 277 | 195 | 52 | do | 300.00 | 200.00 | do | |
| 271 | Reyes Bros | Sec. 11, T. 1 S., R. 14 W. | K-11 | 1901 | do | 370 | 280 | 249 | 53 | Gas | 385.00 | | Irrigation | †3 |
| 272 | G. W. Warner | do | K-11 | | do | 354 | 271 | 98 | 60 | Wind | 120.00 | 100.00 | Domestic | |
| 273 | W. C. Fry | do | K-11 | 1894 | do | 347 | 277 | 275 | 44 | Compressed air | 425.00 | 3,400.00 | Irrigation | |
| 274 | do | do | K-11 | 1888 | do | 351 | 296 | 108 | 33 | Wind | 135.00 | 260.00 | Domestic | |
| 275 | E. C. Hampton | Los Felis | K-11 | 1900 | do | 365 | 200 | 237 | 35 | Gas | 300.00 | 900.00 | Domestic; irrigation. | †8 |
| 276 | H. K. Vickroy | do | K-11 | 1896 | do | 370 | 290 | 291 | 35 | do | 480.00 | | Irrigation; domestic. | †8 |
| 277 | H. Dwire | do | K-11 | 1901 | do | 370 | 290 | 300 | 33 | do | 900.00 | | do | |
| 278 | do | do | K-11 | 1901 | do | 370 | 290 | 380 | | | 500.00 | | Not used | |
| 279 | Mrs. K. T. McFadden | do | L-11 | 1900? | Bored, 8-inch | 365 | 310 | 698 | 24 | Wind | 1,200.00 | 200.00 | Domestic | |
| 280 | E. F. Bogartis | do | K-11 | | Bored, 7-inch | 360 | 287 | 180 | 40 | do | 250.00 | 125.00 | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 281 | L. A. McCray | do | K-11 | 1898 | do | 365 | 280 | 150 | 50 | do | 175.00 | 100.00 | Domestic; irrigation. | |
| 282 | A. H. Mann | do | K-11 | 1900 | do | 338 | 276 | 124 | 44 | do | 135.00 | 150.00 | Domestic | |
| 283 | U. Remida | do | K-11 | 1892 | Dug, 4-foot diameter. | 339 | 277 | 64 | 42 | Hand | | | do | |
| 284 | C. Cole | Sec. 11, T. 1 S., R. 14 W. | J-11 | 1897 | Bored, 7-inch | 357 | 285 | 283 | 54 | Gas | 500.00 | 500.00 | Irrigation | |
| 285 | Mrs. M. C. Gower | do | J-11 | 1883 | do | 350 | 290 | 72 | | Wind, gas | | | Domestic; irrigation. | |
| 286 | Mr. M. Labaig | do | J-11 | 1885 | do | 367 | 281 | 126 | | Wind | 150.00 | 100.00 | Domestic | |
| 287 | Mrs. R. Blondeau | do | J-11 | 1889 | do | 358 | 283 | 92 | | do | | | do | |
| 288 | O. S. Adams | La Brea | J-11 | 1898 | do | 347 | 284 | 200 | 54 | do | 250.00 | 150.00 | do | |
| 289 | H. D. Wilkerson | Sec. 10, T. 1 S., R. 14 W. | J-11 | 1898 | do | 350 | 268 | 100 | | do | 100.00 | | do | |
| 290 | A. L. Reyes | do | J-11 | 1899 | do | 360 | 280 | 150 | 54 | Gas | 175.00 | 300.00 | Domestic; stock | |
| 291 | H. D. Wilkerson | do | J-11 | 1900 | do | 365 | 268 | 160 | 77 | Wind | | | Domestic | |
| 292 | H. J. Whitley | do | J-11 | | do | 360 | 260 | 385 | 86 | Compressed air | | | Irrigation | |
| 293 | Hollywood Cemetery Association. | Sec. 14, T. 1 S., R. 14 W. | J-11 | 1896 | Bored, 10-inch | 310 | 277 | 85 | 26 | Electric motor | | | Domestic; irrigation. | |
| 294 | W. J. Fay | La Brea | J-11 | 1903 | Bored, 6-inch | 309 | 277 | 65 | 33 | Wind | 65.00 | 50.00 | Domestic | |
| 295 | C. W. Walker | do | J-11 | 1893 | Bored, 7-inch | 355 | 265 | 190 | 87 | Gas | 250.00 | 200.00 | Domestic; irrigation. | †2 |
| 296 | Warren Campbell | do | J-11 | | do | 337 | 265 | 93 | | Wind | | | Not used | |
| 297 | W. Squire | do | J-11 | 1900 | do | 348 | 258 | 285 | 84 | Gas | 407.00 | 1,000.00 | Irrigation | |
| 298 | Miss Winsstanley | do | J-11 | 1897 | do | 348 | 258 | 300 | 69 | Wind | | | Domestic | |
| 299 | Mrs. E. J. Boyle | do | J-11 | | do | 332 | 261 | 138 | 72 | do | 200.00 | 150.00 | do | |
| 300 | T. Davidson | do | I-11 | | do | 350 | 261 | 191 | 71 | do | 225.00 | 150.00 | do | |
| 301 | A. Z. Taft | Sec. 11, T. 1 S., R. 14 W. | K-11 | 1893 | do | 398 | 271 | 297 | 57 | do | 520.00 | 215.00 | do | |
| 302 | E. D. Sturdevant | Los Feliis | K-10 | 1902 | do | 425 | 300 | 228 | 60 | Gas | 360.00 | | Domestic; irrigation. | |
| 303 | Ashton Fry | do | K-10 | | Dug, 3-foot diameter. | 450 | 448 | 9 | 53 | Siphon | | | Irrigation | |
| 304 | do | do | K-10 | | Dug, 6-foot diameter. | 450 | 443 | 17 | 43 | do | | | do | |
| 305 | M. Audroda | Sec. 2, T. 1 S., R. 14 W. | K-10 | 1884 | Bored, 7-inch | 440 | 396 | 60 | | | 75.00 | | Not used | |
| 306 | I. W. Lord | do | K-10 | 1888 | Dug, 3 by 3 foot | 490 | 486 | 17 | 131 | Hand | | | Domestic | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 307 | G. H. Freeman | Sec. 2, T. 1 S., R. 14 W. | K-10 | 1897 | Dug, 3 by 3 foot. | 510 | 500 | 25 | 131 | Gas | | | Domestic; irrigation. | |
| 308 | F. Godde | Sec. 11, T. 1 S., R. 14 W. | K-10 | 1891 | Bored, 7-inch | 425 | 385 | 110 | 61 | Wind | | | Domestic | |
| 309 | P. S. Rishel | Sec. 2, T. 1 S., R. 14 W. | K-10 | 1895 | do | 470 | 390 | 108 | 67 | Gas | $125.00 | $500.00 | Irrigation | |
| 310 | do | do | K-10 | 1899 | do | 480 | 422 | 70 | 59 | Wind | 70.00 | 80.00 | Not used | |
| 311 | Frank Fleicher | do | K-10 | 1902 | Dug, 3-foot diameter. | 485 | 447 | 50 | 44 | do | | | Domestic | |
| 312 | F. Godde | do | K-10 | 1902 | Bored, 10-inch | 475 | 414 | 96 | | | 200.00 | | Not used | |
| 313 | Frank Fleicher | do | K-10 | 1903 | Dug, 3-foot diameter. | 500 | 486 | 18 | 61 | Not installed | | | | |
| 314 | F. Godde | Sec. 11, T. 1 S., R. 14 W. | K-10 | 1881 | Bored, 7-inch | 425 | 383 | 78 | 68 | Wind | 100.00 | 100.00 | Domestic | |
| 315 | do | Sec. 2, T. 1 S., R. 14 W. | K-10 | 1883 | Dug, 3 by 3 foot. | 424 | 383 | 52 | | Hand | 75.00 | | do | |
| 316 | do | Sec. 11, T. 1 S., R. 14 W. | K-10 | 1899 | Bored, 7-inch | 420 | 384 | 173 | 64 | Wind | 250.00 | 100.00 | Irrigation | |
| 317 | do | do | K-11 | 1893 | do | 414 | 384 | 115 | 65 | do | 150.00 | 100.00 | do | |
| 318 | J. B. Rapp | Sec. 2, T. 1 S., R. 14 W. | J 10 | 1898 | do | 450 | 380 | 138 | 68 | Gas | 190.00 | 650.00 | do | †5 |
| 319 | do | do | J-10 | 1878 | do | 447 | 380 | 96 | 68 | Wind | 100.00 | 175.00 | Domestic | |
| 320 | Presentcion Lopes | do | J-10 | | do | 430 | 361 | 95 | 75 | do | 100.00 | 100.00 | do | |
| 321 | Mr. Twist | Sec. 11, T. 1 S., R. 14 W. | J-11 | 1886 | do | 380 | 364 | 41 | 55 | do | 50.00 | 75.00 | Domestic; irrigation. | |
| 322 | D. Ammann | Sec. 2, T. 1 S., R. 14 W. | J-10 | 1892? | Dug, 3-foot diameter. | 490 | 434 | 58 | 86 | do | 75.00 | | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 323 | .....do..... | .....do..... | J-10..... | 1896 | .....do..... | 185 | 434 | 76 | 86 | Gas..... | 100.00 | 400.00 | Domestic; irrigation. | ..... |
| 324 | Mrs. Florence Laverty | .....do..... | J-10..... | 1888 | Dug, 4 by 4 foot. | 475 | 444 | 58 | 92 | Wind..... | ..... | ..... | Domestic..... | ..... |
| 325 | .....do..... | .....do..... | J-10..... | 1902 | Bored, 7-inch... | 470 | 410 | 110 | 92 | .....do..... | 185.00 | 210.00 | .....do..... | ..... |
| 326 | M. D. McCaslin..... | .....do..... | J-10..... | 1898 | Dug, 3½-foot diameter. | 480 | 422 | 72 | 83 | .....do..... | 100.00 | 80.00 | .....do..... | ..... |
| 327 | Arthur Letz..... | .....do..... | J-10..... | 1895 | Dug, 3 by 3 foot. | 460 | 428 | 61 | ..... | Gas..... | ..... | ..... | Irrigation..... | ..... |
| 328 | .....do..... | .....do..... | J-10..... | 1900 | .....do..... | 485 | 422 | 105 | 118 | .....do..... | 600.00 | ..... | .....do..... | ..... |
| 329 | H. E. Voorhies..... | .....do..... | J-10..... | 1901 | .....do..... | 445 | 398 | 88 | 84 | .....do..... | ..... | ..... | Not used..... | ..... |
| 330 | .....do..... | .....do..... | J-10..... | ..... | Dug, 3-foot diameter. | 445 | 398 | 100 | 77 | .....do..... | ..... | ..... | Irrigation..... | ..... |
| 331 | R. J. Northana..... | Sec. 10, T. 1 S., R. 14 W. | J-11..... | 1902 | Bored, 10-inch.. | 380 | 300 | 350 | 52 | .....do..... | 500.00 | 1,000.00 | Domestic..... | ..... |
| 332 | E. F. Rankin..... | La Brea..... | J-11..... | 1894 | Bored, 7-inch... | 294 | 269 | 60 | 60 | Wind..... | 60.00 | 100.00 | .....do..... | ..... |
| 333 | Mr. Watts..... | .....do..... | J-11..... | ..... | Dug, 4 by 6 foot. | 298 | 268 | 36 | 59 | .....do..... | 50.00 | 125.00 | .....do..... | ..... |
| 334 | Tom Hudson..... | Sec. 10, T. 1 S., R. 14 W. | J-11..... | 1891? | Bored, 7-inch... | 378 | 275 | 300 | 91 | .....do..... | ..... | ..... | .....do..... | ..... |
| 335 | .....do..... | .....do..... | J-11..... | ..... | .....do..... | 378 | 275 | 150 | 91 | ..... | ..... | ..... | Not used..... | ..... |
| 336 | Mrs. M. P. Moll..... | La Brea..... | J-11..... | 1898 | Bored, 10½-inch. | 377 | 266 | 425 | ..... | Compressed air... | 600.00 | 3,400.00 | Irrigation..... | ..... |
| 337 | .....do..... | .....do..... | I-11..... | 1898 | Bored, 11-inch.. | 382 | 259 | 285 | 32 | Wind..... | 350.00 | 200.00 | Domestic..... | ..... |
| 338 | J. Glass..... | Sec. 9, T. 1 S., R. 14 W. | I-11..... | ..... | ..... | 390 | ..... | ..... | ..... | Gas..... | ..... | ..... | Irrigation..... | ..... |
| 339 | C. F. Wagner..... | .....do..... | I-11..... | 1897 | Bored, 7-inch... | 400 | 190 | 468 | 47 | Wind..... | 600.00 | 400.00 | Domestic..... | ..... |
| 340 | Will Sommerville..... | .....do..... | I-11..... | 1902 | Bored, 10-inch.. | 500 | 414 | 112 | 45 | Electric motor.... | ..... | ..... | Domestic; irrigation. | ..... |
| 341 | Alfred Solano..... | .....do..... | I-10, 11.. | 1902 | .....do..... | 525 | 420 | 145 | 40 | .....do..... | ..... | ..... | .....do..... | ..... |
| 342 | R. B. Lyon..... | .....do..... | I-11..... | 1894 | Bored, 7-inch... | 338 | 238 | 285 | 52 | Gas..... | 400.00 | 600.00 | Domestic..... | ..... |
| 343 | E. C. Harrington..... | .....do..... | I-11..... | 1896 | Bored, 10-inch.. | 338 | 221 | 300 | 54 | .....do..... | 425.00 | 400.00 | Irrigation..... | ..... |
| 344 | T. M. Beaty..... | .....do..... | I-11..... | 1888 | Bored, 7-inch... | 340 | 261 | 121 | 54 | Wind..... | 150.00 | 75.00 | Domestic..... | ..... |
| 345 | Schryver & Crosby ... | Los Feliis..... | M-11..... | 1891 | Dug, 4 by 4 foot. | 412 | 359 | 60 | 101 | .....do..... | ..... | ..... | .....do..... | ..... |
| 346 | H. Schreyder..... | .....do..... | M-11..... | 1891 | Bored, 12-inch.. | 390 | 357 | 400 | 101 | Gas; wind..... | ..... | ..... | Irrigation..... | ..... |
| 347 | Mary A. McHale..... | Los Angeles city.. | M-11..... | 1890 | Dug, 3 by 3 foot. | 345 | 326 | 24 | 180 | Hand..... | ..... | ..... | Domestic..... | ..... |
| 348 | Mrs. Mary Martin..... | Los Feliis..... | M-11..... | 1899 | Bored, 12-inch.. | 405 | 380 | 1,100 | ..... | ..... | ..... | ..... | Not used..... | ..... |
| 349 | E. A. Knapp..... | .....do..... | L-11..... | 1885 | Dug, 3½-foot diameter. | 370 | 271 | 106 | 26 | Wind..... | ..... | ..... | Domestic..... | ..... |
| 350 | Mrs. R. H. Chambers.. | .....do..... | L-11..... | 1901 | Bored, 8-inch... | 392 | 324 | 131 | 30 | .....do..... | 150.00 | 100.00 | .....do..... | ..... |
| 351 | E. L. Haskins..... | .....do..... | L-11..... | 1897 | Bored, 7-inch... | 375 | 327 | 75 | 30 | .....do..... | 100.00 | 100.00 | .....do..... | ..... |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of wells. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 352 | Mrs. M. B. Kenyon | Los Felis | L-11 | 1898 | Bored, 7-inch | 370 | 327 | 107 | 32 | Wind | $150.00 | $100.00 | Domestic | |
| 353 | H. Klages | do | L-11 | 1886 | do | 385 | 321 | 114 | 25 | do | 130.00 | 125.00 | do | |
| 354 | Mrs. S. Gunn | Sec. 8, T. 1 S., R. 13 W. | L-11 | 1893 | Dug, 3½ by 3½ foot. | 362 | 304 | 59 | 24 | do | 70.00 | 125.00 | do | |
| 355 | Fred Gross | do | M-11 | 1878 | Dug, 4-foot diameter. | 360 | 315 | 52 | 119 | do | | 100.00 | do | |
| 356 | J. H. Moore | Sec. 18, T. 1 S., R. 13 W. | M-11 | 1903 | Bored, 5½-inch | 320 | 292 | 33 | 101 | Hand | 40.00 | | Not used | |
| 357 | N. B. Walker | do | L-11 | 1903 | Bored, 6-inch | 325 | 311 | 57 | 33 | do | 50.00 | | Domestic | |
| 358 | J. Nass | Sec. 8, T. 1 S., R. 13 W. | L-11 | 1895 | Dug, 3-foot diameter. | 330 | 312 | 23 | 29 | Wind | | | do | |
| 359 | R. Ybarra | Sec. 18, T. 1 S., R. 13 W. | L-11 | 1901 | Dug, 4 by 4 foot. | 325 | 312 | 18 | 45 | Hand | | | do | |
| 360 | Nickolas Priester | Sec. 12, T. 1 S., R. 14 W. | L-11 | 1881 | Dug | 328 | 310 | 23 | 58 | Wind | 30.00 | 75.00 | Domestic; irrigation. | |
| 361 | D. Sullivan | Sec. 13, T. 1 S., R. 14 W. | L-12 | 1894 | Dug, 4 by 4 foot. | 320 | 291 | 35 | 58 | do | | | Domestic | |
| 362 | C. O. Randall | Sec. 7, T. 1 S., R. 13 W. | L-11 | 1898 | Dug, 3½-foot diameter. | 335 | 315 | 25 | 23 | do | 30.00 | 100.00 | do | |
| 363 | John Bartell | Sec. 12, T. 1 S., R. 14 W. | L-11 | 1901 | Bored, 12-inch | 337 | 309 | 65 | 33 | do | 75.00 | | do | |
| 364 | May B. Bright | Los Felis | L-11 | | Bored, 7-inch | 348 | 314 | 50 | 78 | do | 50.00 | 150.00 | do | |
| 365 | Miss Wheeler and Mrs. Skinner. | do | L-11 | | Dug, 2½-foot diameter. | 350 | 314 | 41 | 200+ | do | 50.00 | 150.00 | do | |
| 366 | Nickolas Priester | Sec. 12, T. 1 S., R. 14 W. | L-11 | 1900 | Dug, 4½ by 4½ foot. | 347 | 315 | 41 | 101 | do | 50.00 | 50.00 | do | |
| 367 | Mrs. K. Pates | Los Felis | L-11 | 1893 | Dug, 6 by 6 foot. | 348 | 313 | 65 | 53 | do | 75.00 | 100.00 | do | |
| 368 | Mrs. Fellows | do | L-11 | | Bored, 7-inch | 380 | 319 | 63 | | do | 75.00 | 100.00 | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 369 | C. Boehucke | Sec. 18, T. 1 S., R. 13 W. | L-11 | 1895 | Dug, 3-foot diameter. | 320 | Dry. | 24 | | | | | | |
| 370 | Wm. Lehnhardt | do | L-12 | | Dug, 6-foot diameter. | 297 | 281 | 25 | 45 | Wind | 35.00 | 100.00 | Domestic | |
| 371 | E. F. Henderson | do | L-12 | 1888 | Dug, 3-foot diameter. | 285 | 269 | 25 | 66 | Hand | | | Domestic; stock | |
| 372 | Mr. Atkinson | Sec. 13, T. 1 S., R. 14 W. | L-12 | | Dug, 4 by 4 foot. | 285 | 265 | 30 | 92 | Wind | 35.00 | 65.00 | Domestic | |
| 373 | Mrs. M. J. McConnell | do | L-12 | 1890 | Dug, 3-foot diameter. | 285 | 267 | 18 | 30 | do | 50.00 | 75.00 | do | |
| 374 | E. T. Yerxa | do | L-12 | | Dug, 4-foot diameter. | 285 | 265 | 30 | 40 | do | 50.00 | 100.00 | do | |
| 375 | do | do | L-12 | | Dug, 4 by 4 foot. | 280 | 265 | 30 | 41 | Electric motor | 45.00 | 200.00 | Irrigation | |
| 376 | F. P. Chaffee | do | L-12 | 1900 | do | 301 | 270 | 40 | 42 | Wind | 50.00 | 175.00 | Domestic | |
| 377 | Chas. Hert | do | L-12 | 1901 | Dug, 4-foot diameter. | 300 | 264 | 56 | 52 | do | 75.00 | 150.00 | Domestic; irrigation. | |
| 378 | A. L. Hodges | do | K-12 | 1895 | Dug, 3½-foot diameter. | 300 | 264 | 45 | 31 | do | 50.00 | 75.00 | Domestic | |
| 379 | Mrs. W. Newman | do | L-12 | 1885 | Dug, 4 by 4 foot. | 305 | 281 | 26 | 37 | do | 35.00 | 75.00 | do | |
| 380 | F. P. Chaffee | do | L-12 | 1902 | Dug, 3½ by 3½ foot. | 320 | 289 | 50 | 40 | do | 65.00 | 125.00 | do | |
| 381 | E. Hahn | do | L-11 | 1895 | Dug, 5 by 5 foot. | 325 | 284 | 45 | 47 | do | 60.00 | 75.00 | do | |
| 382 | Wm. Priester | Sec. 12, T. 1 S., R. 14 W. | L-11 | 1899 | Bored, 16-inch | 325 | 285 | 47 | 125 | do | 75.00 | 100.00 | do | |
| 383 | Mrs. Basley | do | L-11 | 1896 | Dug, 3½ by 3½ foot. | 330 | 285 | 57 | 123 | do | 75.00 | 100.00 | do | |
| 384 | C. Jenkins | do | L-11 | 1898 | Dug, 3-foot diameter. | 330 | 276 | 58 | 76 | do | 75.00 | 80.00 | do | |
| 385 | do | do | L-11 | 1902 | Dug, 4-foot diameter. | 330 | 277 | 68 | 53 | do | 100.00 | 75.00 | Domestic; irrigation. | |
| 386 | John Rehfuss | Sec. 13, T. 1 S., R. 14 W. | K-11 | 1899 | do | 325 | 277 | 60 | 58 | do | 75.00 | 65.00 | Domestic | |
| 387 | Geo. P. Swan | do | K-11 | 1896 | Bored, 7-inch | 320 | 283 | 76 | 37 | do | 100.00 | 100.00 | do | |
| 388 | German Church | do | K-11 | 1897 | do | 320 | 283 | 57 | 39 | do | 75.00 | 100.00 | Domestic; irrigation. | |
| 389 | Philip Schneider | Sec. 12, T. 1 S., R. 14 W. | K-11 | 1896? | Dug, 4-foot diameter. | 325 | 279 | 58 | 33 | do | 75.00 | 150.00 | Domestic | |
| 390 | Mr. Young | do | K-11 | 1898? | Bored, 7-inch | 325 | 276 | 60 | 46 | do | 75.00 | 100.00 | do | |
| 391 | L. F. Bowker | do | K-11 | 1896 | Dug, 4 by 4 foot. | 322 | 286 | 45 | 36 | do | 55.00 | 75.00 | do | |
| 392 | J. Stansfield | do | K-11 | 1903 | Bored, 6-inch | 325 | 280 | 62 | 29 | Hand | 46.50 | | do | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 393 | S. C. Stevenson | Sec. 12, T. 1 S., R. 14 W. | K, L-11 | 1903 | Bored, 6-inch | 320 | 280 | 61 | 29 | Hand | $45.75 | | Domestic | |
| 394 | Mr. Cornell | do | K, L-11 | 1903 | do | 340 | 286 | 60 | 41 | | 45.00 | | Not installed | |
| 395 | R. C. Kaestner | Sec. 13, T. 1 S., R. 14 W. | K-12 | 1898 | Dug, 4 by 4 foot | 310 | 270 | 50 | 40 | Wind | 75.00 | $100.00 | Domestic | |
| 396 | Clara Lawrence | do | K-12 | | Bored, 7-inch | 315 | 286 | 48 | 59 | do | 50.00 | 75.00 | do | |
| 397 | Fred F. Wheeler | Los Angeles city | M-13 | 1895 | Bored, 7⅝-inch | 305 | 303 | 500 | 150+ | do | 1,200.00 | 125.00 | Irrigation | |
| 398 | L. A. P. Rwy. Co | do | L-13 | 1903 | Bored, 9⅝-inch | 250 | | 300+ | | | | | | |
| 399 | A. H. Hedley | do | M-12 | 1902 | Bored, 7⅝-inch | 390 | 355 | 630 | | Hand | 1,000.00 | | Domestic | |
| 400 | E. J. Wilbur | Sec. 14, T. 1 S., R. 14 W. | K-11, 12 | 1894 | Bored, 6½-inch | 315 | 277 | 70 | 50 | Electric motor | | | Domestic; irrigation. | |
| 401 | Wm. Priester | Sec. 12, T. 1 S., R. 14 W. | L-11 | 1889 | Dug, 4 by 4 foot | 335 | 287 | 62 | 60 | Wind | 80.00 | 75.00 | Domestic | |
| 402 | do | do | L-11 | | do | 335 | 286 | 55 | 59 | do | 75.00 | 75.00 | Irrigation | |
| 403 | Mrs. J. B. Skinner | Sec. 18, T. 1 S., R. 13 W. | L-12 | 1895 | Bored, 7-inch | 285 | 277 | 25 | 200+ | do | 30.00 | 75.00 | Domestic; irrigation. | |
| 404 | S. J. Jappel | do | L-12 | 1896 | Dug, 3-foot diameter. | 290 | 274 | 23 | 200+ | do | 35.00 | 100.00 | Domestic | |
| 405 | Sarah Hill | do | L-12 | 1891 | Dug, 3½ by 3½ foot. | 290 | 273 | 25 | 96 | do | 35.00 | 100.00 | do | |
| 406 | Mr. Heard | do | L-12 | 1896 | Dug, 3 by 3 foot. | 280 | 269 | 16 | 95 | Hand | 20.00 | | do | |
| 407 | H. Fastenau | do | L-12 | 1895 | Bored, 7-inch | 280 | 268 | 40 | 134 | Wind | 50.00 | 125.00 | do | |
| 408 | G. W. Albright | do | L-12 | 1896 | Dug, 3-foot diameter. | 270 | 265 | 9 | 200+ | do | | | do | |
| 409 | Wm. Jessup | do | L-12 | 1900 | Dug, 4-foot diameter. | 300 | 292 | 25 | 200+ | do | | | do | |
| 410 | W. E. Lord | Los Angeles city | L-12 | 1901 | do | 250 | 192 | 68 | 138 | do | | | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 411 | John W. Mitchell | Sec. 24, T. 1 S., R. 14 W. | L-13 | 1901 | Bored, 9⅝-inch | 255 | | 450 | | | | | Not used | |
| 412 | D. W. Edwards | Los Angeles city | L-13 | 1900 | Bored, 12-inch | 260 | 260 | 1,750 | | Artesian | | | Baths | 15 |
| 413 | Irey Barrow | Sec. 13, T. 1 S., R. 14 W. | L-12 | 1883 | Dug, 2½-foot diameter. | 280 | 278 | 70 | 15 | Hand | | | Domestic | |
| 414 | do | do | L-12 | 1883 | Dug 4 by 4 foot | 270 | 269 | 5 | 35 | do | | | do | |
| 415 | do | do | L-12 | 1873 | Dug, 3½-foot diameter. | 275 | 262 | 30 | 103 | do | 50.00 | | Irrigation | |
| 416 | Hulda Brawn | do | L-12 | 1899? | Dug, 4 by 4 foot | 275 | 248 | 30 | 168 | Wind | 45.00 | 75.00 | Domestic | |
| 417 | E. D. Music | do | L-12 | 1897? | do | 300 | 253 | 60 | 125 | do | 75.00 | 85.00 | do | |
| 418 | T. J. Read | Sec. 14, T. 1 S., R. 14 W. | K-12 | 1894 | Bored, 7-inch | 305 | 267 | 70 | 37 | do | 85.00 | 150.00 | do | |
| 419 | A. Birklein | do | K-12 | 1895 | do | 305 | 268 | 75 | 45 | Gas | 100.00 | 400.00 | Domestic; irrigation. | |
| 420 | do | do | K-12 | 1902 | do | 305 | 268 | 70 | 47 | Wind | 85.00 | 196.00 | Irrigation | |
| 421 | L. W. Myers | do | K-12 | | do | 300 | 264 | 90 | 39 | Gas | 100.00 | 400.00 | Domestic; irrigation. | |
| 422 | B. Witherell | Sec. 13, T. 1 S., R. 14 W. | K-12 | 1902 | do | 300 | 270 | 80 | | Wind | 80.00 | 85.00 | | |
| 423 | B. Duin | do | K-12 | 1873 | Dug, 4-foot diameter. | 300 | 268 | 40 | 42 | do | | | Domestic | |
| 424 | do | do | K-12 | 1900 | Bored, 10-inch | 300 | 300 | 540 | | | 2,000.00 | | Not used | |
| 425 | W. A. Gooding | Sec. 14, T. 1 S., R. 14 W. | K-12 | 1891 | Bored, 7-inch | 295 | 260 | 43 | 39 | Wind | 50.00 | 75.00 | Domestic | |
| 426 | H. Schulthis | Sec. 13, T. 1 S., R. 14 W. | K-12 | 1902 | do | 290 | 270 | 115 | 84 | Gas | 125.00 | 350.00 | Domestic; irrigation. | |
| 427 | do | do | K-12 | 1893? | do | 290 | 267 | 70 | | Wind | 75.00 | 75.00 | Irrigation | |
| 428 | Fred Schmidt | Sec. 24, T. 1 S., R. 14 W. | L-13 | 1901 | Bored, 7⅝-inch | 275 | 245 | 525 | | | 2,000.00 | | | |
| 429 | H. B. Kelsey | do | L-13 | 1900 | Bored, 6-inch | 270 | | 300 | | | 500.00 | | | |
| 430 | do | do | L-13 | 1875 | Dug, 3-foot diameter. | 275 | 232 | 53 | 80 | Hand | | | Domestic | |
| 431 | Mrs. M. L. Frary | Sec. 13, T. 1 S., R. 14 W. | K-12 | 1901 | Bored, 5⅝-inch | 280 | 280 | 296 | | | 500.00 | | Not used | |
| 432 | V. A. Pernot estate | Sec. 14, T. 1 S., R. 14 W. | K-11 | 1897 | Bored, 7-inch | 310 | 273 | 85 | 52 | Wind | 100.00 | 125.00 | Domestic | |
| 433 | Robert Lewis | do | K-11 | 1901 | Bored, 10-inch | 310 | 310 | 1,284 | 200+ | Artesian | | | Irrigation | |
| 434 | Mrs. Eliza Wade | do | K-12 | 1888 | Dug, 3 by 3 foot | 295 | 257 | 45 | 50 | Wind | 50.00 | 100.00 | Domestic | |
| 435 | Stoll estate | do | K-12 | 1898 | Bored, 7-inch | 288 | 257 | 65 | 37 | do | 75.00 | 100.00 | do | |
| 436 | L. Huber | do | K-12 | 1893 | Dug, 3 by 4 foot | 275 | 253 | 25 | 46 | do | | | do | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 437 | W. P. Moon & Co. | Sec. 24, T. 1 S., R. 14 W. | K-13 | 1901 | Bored, 7⅞-inch | 245 | 245 | 625 | 114 | Artesian | $1,500.00 | | | |
| 438 | Carl Hoechlin | Sec. 14, T. 1 S., R. 14 W. | K-12 | 1886 | Dug, 2½ by 2½ foot. | 275 | 252 | 25 | 60 | Wind | 50.00 | $100.00 | Domestic | |
| 439 | do | do | K-12 | 1902 | Bored, 7-inch | 275 | 273 | 500 | | | 1,000.00 | | Not used | |
| 440 | J. Bailey | do | J, K-12 | 1902 | Dug, 3-foot diameter. | 275 | 247 | 37 | 47 | Wind | 50.00 | 125.00 | Domestic | |
| 441 | S. A. Crumrine | do | K-11 | | Bored, 7-inch | 310 | 266 | 50 | 68 | do | 75.00 | 100.00 | do | |
| 442 | do | do | K-11 | | do | 310 | 269 | 44 | 69 | | 65.00 | | Not used | |
| 443 | Mr. I. A. Weld | do | K-12 | 1868 | Dug, 4 by 4 foot | 280 | 264 | 23 | 72 | Hand | | | Domestic | |
| 444 | do | do | K-12 | 1896 | Bored, 8-inch | 285 | 285 | 825 | 171 | Artesian | | | Irrigation | (a) |
| 445 | Mr. Gus Runebeck | Sec. 13, T. 1 S., R. 14 W. | K-12 | | Dug, 3 by 4 foot. | 283 | 265 | 25 | 134 | Wind | 35.00 | 75.00 | Domestic; stock | |
| 446 | Mrs. Mary Hall | do | K-12 | | Dug, 3½ by 3½ foot. | 291 | 264 | 35 | 92 | Hand | | | Domestic | |
| 447 | Mr. Merryfield | Sec. 24, T. 1 S., R. 14 W. | K-12, 13 | | Dug, 3 by 3 foot. | 260 | 227 | 46 | 133 | Wind | 50.00 | 65.00 | Stock | |
| 448 | Mrs. S. Shepherd | do | K-12 | | Dug, 4 by 4 foot. | 260 | 229 | 42 | 43 | do | | | Domestic | |
| 449 | J. M. Southworth | do | K-13 | 1902 | Bored, 7-inch | 250 | 210 | 80 | | do | 100.00 | 100.00 | do | |
| 450 | do | do | K-13 | 1901 | Bored | 235 | 235 | 500 | | | | | Not used | |
| 451 | Ed. Glass | do | L-13 | 1903 | Bored, 7-inch | 270 | 216 | 200 | 116 | Wind | 200.00 | 75.00 | Domestic | |
| 452 | Ed. Gird | do | L-13 | 1891 | do | 260 | 194 | 83 | 106 | do | 100.00 | 75.00 | do | |
| 453 | do | do | L-13 | | do | 250 | 194 | 75 | 98 | do | 90.00 | 75.00 | Stock; irrigation | |
| 454 | G. L. Schmidt | Los Angeles city | L-13 | | Dug, 3 by 6 foot. | 195 | 187 | 12 | 133 | do | 25.00 | 75.00 | Stock | |
| 455 | Edward Schmidt | Sec. 21, T. 1 S., R. 14 W. | L-13 | 1875 | Dug, 4 by 4 foot. | 205 | 202 | 15 | 200+ | do | 25.00 | 75.00 | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 458 | J. L. Plummer | Sec. 25, T. 1 S., R. 14 W. | K-13 | 1897 | Bored, 7-inch | 230 | 211 | 45 | | do | | | Domestic | | |
| 459 | Geo. Simmons | do | K-13 | 1900 | Bored, 9½-inch | 238 | | | | Artesian | | | | | 10 |
| 460 | do | do | K-13 | 1901 | do | 237 | | | | | | | | | |
| 461 | Will Thornton | do | J-13 | 1901 | Hydraulic, 4-inch. | 238 | | 834 | | | | | | | |
| 462 | F. & J. Pellissier | Los Angeles city | K-14 | 1902 | Bored, 10-inch | 200 | 177 | 90 | 140 | Wind | | | Domestic; stock | | |
| 463 | do | do | K-14 | 1895 | Dug, 6-foot diameter. | 189 | 177 | 40 | 190 | do | | | Stock | | |
| 464 | Mr. Pellissier | do | K-14 | | Dug, 6 by 6 foot. | 202 | 186 | 25 | 172 | do | | | Domestic | | |
| 465 | Mr. O. W. Lewis | do | K-14 | | Dug, 4 by 4 foot. | 185 | 160 | 26 | 170 | | 50.00 | | Not used | | |
| 466 | John Sotterwhite | do | K-14 | 1897 | Bored | 190 | 155 | 50 | 160 | Wind | 60.00 | 100.00 | Irrigation | | |
| 467 | Mr. Prudens | do | K-14 | 1900 | Bored, 7-inch | 200 | 160 | 50 | 150 | do | 60.00 | 100.00 | Domestic | | |
| 468 | M. C. Teatsworth | do | K-14 | 1896 | do | 205 | 171 | 50 | 177 | do | 60.00 | 100.00 | Irrigation | | |
| 469 | Robert Pompey | do | L-14 | 1899 | do | 200 | Dry. | 37 | | | 50.00 | 75.00 | | | |
| 470 | Orin Capito | do | L-14, 15 | | do | 230 | 147 | 100 | 97 | Wind | 125.00 | 75.00 | Domestic | | |
| 471 | Mary Anderson | do | L-14 | 1883 | do | 230 | 156 | 85 | 63 | do | 100.00 | 100.00 | do | | |
| 472 | L. Longstrom | do | L-14 | | Dug, 3½ by 3½ foot. | 240 | 184 | 60 | | do | 75.00 | 75.00 | Not used | | |
| 473 | C. E. Bridges | Sec. 14, T. 1 S., R. 14 W. | J-12 | 1883 | Dug, 4 by 4 foot. | 264 | 243 | 30 | 72 | do | 50.00 | 75.00 | Domestic; irrigation. | | |
| 474 | J. Zazoux | do | K-12 | 1878 | Dug | 255 | 251 | 10 | 64 | do | | | Domestic | | |
| 475 | Mr. Cole | La Brea | J-12 | | Bored, 12-inch | 275 | 275 | | 200+ | Artesian | | | | | (a) |
| 481 | F. P. Shoemaker | do | I-13 | 1885 | Bored, 7-inch | 215 | 199 | 82 | 69 | Wind | | | Domestic | | |
| 482 | Mrs. Ida Hancock | do | I-13 | | Dug, 2 by 3 foot. | 200 | 186 | 20 | 76 | do | | | Domestic; stock | | |
| 483 | A. F. Gilmore | do | H-13 | 1876 | Dug, 15 by 20 foot. | 205 | 203 | 14 | 81 | do | | 75.00 | do | | |
| 484 | Mrs. Ida Hancock | do | I-13 | 1897 | Dug, 4 by 4 foot. | 225 | 189 | 38 | 80 | do | | 75.00 | do | | |
| 485 | do | do | I-12 | 1883 | Dug, 3 by 3 foot. | 230 | 207 | 25 | | do | 30.00 | | do | | |
| 486 | do | do | I-12 | 1891 | do | 245 | 209 | 38 | 66 | do | 50.00 | | do | | |
| 487 | J. S. Thrasher | do | I-12 | | do | 287 | 251 | 36 | 65 | Hand | 50.00 | | Domestic | | |
| 488 | E. L. Baker | do | I-11 | | Bored, 10-inch | 321 | 250 | 259 | 63 | Wind | 400.00 | 100.00 | do | | |
| 489 | Geo. Lingo | do | I-11 | 1901 | Bored, 7-inch | 315 | 259 | 100 | 69 | Hand | 100.00 | 25.00 | do | | |
| 490 | Price & Whitmore | do | I-11 | | do | 305 | 255 | 120 | 62 | Gas | 150.00 | | Irrigation; domestic. | | |
| 491 | R. O. Robinson | do | I, J-11 | 1887 | do | 305 | 265 | 100 | 77 | Wind | 125.00 | 75.00 | Domestic | | |

[a] Small.

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 492 | Mrs. M. J. Rogers | Las Cienegas | I-14 | 1878 | Bored, 18-inch | 175 | 160 | 25 | 123 | Hand | | | Domestic | |
| 493 | do | do | I-14 | 1878 | Dug, 3 by 3 foot | 170 | 165 | 10 | 125 | do | | | Stock | |
| 494 | L. P. Mansfield | do | I-13 | | Dug, 4 by 4 foot | 150 | 138 | 20 | 89 | do | | | Domestic | |
| 496 | Mr. R. E. Hulburt | do | I-13 | 1885 | Bored, 7-inch | 180 | 162 | 84 | 58 | Wind | $100.00 | $75.00 | do | |
| 497 | Mrs. Ida Hancock | La Brea | J-13 | | Dug, 3 by 3 foot | 170 | 163 | 15 | 78 | Hand | | | Domestic; stock | |
| 498 | Mrs. L. Smith | Las Cienegas | J-14 | 1902 | Dug, 3 by 4 foot | 148 | 139 | 12 | 96 | do | | | Domestic | |
| 499 | Susan Hardy | do | K-14 | | Dug, 3 by 3 foot | 150 | 139 | 15 | 200+ | Wind | | 50.00 | Stock; domestic | |
| 500 | Lucy Vanderwort | do | J-14 | 1891 | Bored, 7-inch | 186 | 130 | 85 | 96 | do | | | Domestic | |
| 501 | do | do | J-14 | | do | 187 | 130 | 70 | 86 | do | | 75.00 | do | |
| 502 | Wm. Auderes | do | J-14 | 1886 | do | 168 | 125 | 140 | 86 | do | 160.00 | 100.00 | do | |
| 503 | E. Jennison | do | J-14 | 1901 | Dug, 5 by 5 foot | 186 | 130 | 65 | 80 | do | | | Factory | |
| 504 | C. W. Brashear | do | I-14 | 1902 | Dug, 3 by 3 foot | 210 | 197 | 20 | 107 | do | 35.00 | 125.00 | Irrigation | |
| 505 | do | do | I-14 | | Dug, 18-inch | 216 | 197 | 27 | 101 | do | 40.00 | 100.00 | Domestic | |
| 507 | Mrs. Mary Masselin | do | I-13 | 1883 | Dug, 6 by 6 foot | 209 | 197 | 30 | 86 | do | 50.00 | 100.00 | do | |
| 508 | Mrs. Ida Hancock | La Brea | I-13 | 1902 | Dug, 4-foot diameter. | 200 | 195 | 10 | 101 | do | 25.00 | 100.00 | do | |
| 509 | do | do | I-13 | 1880 | Dug, 6 by 6 foot | 199 | 195 | 9 | 103 | do | 25.00 | 75.00 | Domestic; stock | |
| 512 | H. O. Pickrel | do | H-14 | 1899 | Bored, 10-inch | 125 | 88 | 200 | 74 | do | 400.00 | 100.00 | Domestic | |
| 513 | C. Grewe | do | G-14 | 1883 | Dug, 4 by 4 foot | 110 | 96 | 15 | 84 | do | 25.00 | 75.00 | do | |
| 514 | J. H. Whitworth | do | G-14 | 1887 | Bored, 6-inch | 125 | 114 | 61 | 80 | do | 75.00 | 75.00 | do | |
| 515 | do | do | G-13 | 1898 | Bored, 8-inch | 140 | 129 | 150 | 68 | Gas | 200.00 | 600.00 | Irrigation | 60 |
| 516 | do | do | G-13 | 1898 | Bored, 9-inch | 139 | 129 | 150 | 68 | do | 200.00 | | do | |
| 517 | do | do | G-13 | 1898 | Bored, 6 inch | 138 | 129 | 257 | 68 | | 300.00 | | Not used | |
| 518 | Wm. Niles | do | G-13 | | Bored, 14-inch | 170 | 164 | 150 | 103 | Wind | 200.00 | 65.00 | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 519 | .....do | .....do | G-12 | | .....do | 180 | 180 | 160 | 72 | Artesian | | | Irrigation | †3 |
| 520 | Rommel Oil Co. | Rodeo de Las Aguas. | H-14 | | Dug, 4 by 4 foot. | 151 | 123 | 48 | 98 | Gas | | | Oil wells | |
| 521 | J. H. Whitworth | .....do | H-14 | 1883 | Bored, 7-inch | 145 | 116 | 90 | 84 | Wind | 100.00 | 75.00 | Domestic | |
| 522 | .....do | .....do | H-14 | 1902 | .....do | 150 | 116 | | 56 | | | | Not used | |
| 525 | W. H. Mansfield | Las Cienegas | H-14 | 1902 | Dug, 4 by 8 foot, 22 feet; bored, 9⅞-inch, 168 feet. | 120 | 118 | 190 | 85 | Gas | 350.00 | 450.00 | Irrigation | 35 |
| 526 | .....do | .....do | H-14 | 1880? | Bored, 7-inch | 155 | 111 | 61 | 98 | Wind | 75.00 | 100.00 | Domestic | |
| 527 | Mrs. Tenoni | .....do | H-14 | | Dug, 4 by 4 foot. | 120 | 119 | 12 | | .....do | 25.00 | 75.00 | Stock | |
| 528 | Manuel Slier (tenant) | .....do | H-14 | | .....do | 140 | 132 | 12 | 145 | Hand | 100.00 | | Domestic | |
| 529 | Mrs. T. Coyle | .....do | H, 1-14 | | .....do | 155 | 140 | 20 | 160 | .....do | | | .....do | |
| 530 | Wm. Greve | .....do | I-14 | 1890 | Bored, 7-inch | 182 | 135 | 60 | 70 | Wind | 75.00 | 75.00 | .....do | |
| 531 | Mrs. Mary Masselin | .....do | I-14 | | Dug, 18-inch | 210 | 182 | 30 | 125 | Hand | 50.00 | | Stock | |
| 532 | J. A. Clark | .....do | I-14 | 1895 | Dug, 4 by 4 foot. | 163 | 135 | 31 | 58 | Wind | | | Domestic | |
| 533 | Julius Hauser | .....do | I-14 | 1900 | Bored, 12-inch | 140 | 140 | 425 | 36 | Artesian | | | Manufacturing | 5 |
| 534 | .....do | .....do | H-15 | 1889 | | 150 | 120 | 150 | | | | | | |
| 535 | .....do | .....do | H-15 | 1895 | Bored, 6-inch | 130 | 130 | 388 | 36 | Artesian | | | Duck pond | 3 |
| 536 | A. D. Keating | .....do | I-14 | | Bored, 12-inch | 155 | 152 | | 134 | Hand | | | Stock | |
| 537 | Rosedale Cemetery Association. | .....do | I-14 | | Dug, 4 by 4 foot. | 150 | 116 | 40 | 96 | Wind | | 75.00 | Domestic | |
| 538 | .....do | .....do | I-14 | | Bored, 12-inch | 140 | 127 | 870 | 76 | | | | Not used | |
| 539 | .....do | .....do | I-14 | | .....do | 140 | 127 | 162 | 76 | | | | .....do | |
| 540 | A. D. Keating | .....do | I-14 | 1903 | Dug, 3-foot diameter. | 120 | 116 | 6 | 84 | Hand | | | Domestic | |
| 541 | Cienega school district. | .....do | I-14 | 1893? | Dug, 3 by 3 foot. | 140 | 127 | 17 | 86 | Wind | 25.00 | 75.00 | .....do | |
| 542 | L. A. P. Rwy. Co. | .....do | J-14 | 1903 | Bored, 12-inch | 135 | 112 | 100 | 76 | Electric motor | 200.00 | | Engines | |
| 543 | Mrs. A. H. Chalmers | .....do | J-14 | 1902 | Bored | 152 | 110 | 183 | 70 | Wind | 250.00 | 150.00 | Domestic | |
| 544 | P. F. Wise | .....do | J-14 | 1895 | Bored, 7-inch | 155 | 109 | 83 | 79 | .....do | 100.00 | 100.00 | .....do | |
| 545 | A. D. Keating | .....do | I-15 | | Bored, 12-inch | 145 | 133 | | 160 | .....do | | 250.00 | Domestic; stock | |
| 546 | Julius Hauser | .....do | H-15 | | Dug, 4 by 4 foot. | 135 | 116 | 25 | 200+ | .....do | | | Domestic | |
| 547 | Mrs. Ida Hancock | La Brea | I-12 | | .....do | 240 | 218 | 23 | | Hand | 35.00 | | Stock | |
| 548 | S. R. McClellan | .....do | I-11 | | Bored, 7-inch | 350 | 273 | 150? | 60 | Wind | 100.00 | | Domestic; irrigation. | |
| 549 | S. W. Price | .....do | I-11 | 1897 | .....do | 345 | 271 | 160 | 66 | Gas | 200.00 | 75.00 | Domestic | |
| 550 | Loren Allen | .....do | I-11 | 1893 | .....do | 343 | 271 | 105 | 29 | Wind | 125.00 | 100.00 | Domestic; irrigation. | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 551 | Mrs. A. T. De Steiger | La Brea | I-11 | | Bored, 7-inch | 352 | 272 | 200 | 64 | Wind, gas | | | Domestic; irrigation. | |
| 574 | Ballona Water Co | Las Cienegas | H-15 | | Bored, 6-inch | 98 | 98 | 150 | 85 | Artesian | | | Irrigation | Small |
| 575 | do | do | H-15 | 1902 | Bored, 12-inch | 98 | 98 | 464 | 101 | do | | | do | †12 |
| 576 | do | do | H-15 | 1903 | do | 97 | 97 | 520 | 103 | do | | | do | 7 |
| 577 | F. Rimpan | do | I-16 | 1903? | do | 100 | 97 | 125 | 52 | Not installed | | | | |
| 57. | A. D. Keating | do | I-15 | | Bored, 8-inch | 100 | 100 | 1,200 | 47 | Artesian | | | Irrigation | 3 |
| 579 | Mr. Bull | do | H-15 | | Bored, 7-inch | 97 | 97 | | 52 | do | | | Domestic | 1.6 |
| 580 | do | do | H-15 | | do | 97 | 97 | | 52 | do | | | Irrigation | |
| 581 | do | do | H-15 | | do | 97 | 97 | | 52 | do | | | | †2 |
| 582 | A. D. Keating | do | H-15 | | Dug, 3 by 3 foot | 89 | 84 | 8 | 140 | Hand | | | Domestic; stock | |
| 583 | Dora Marxen | do | H-15 | 1900? | Dug, 4 by 4 foot | 89 | 83 | 14 | 200+ | do | | | Domestic | |
| 584 | do | do | H-15 | 1875? | Bored, 7-inch | 87 | 85 | 35 | 200+ | | | | Not used | |
| 585 | Ballona Water Co | do | H-15 | 1900 | Bored, 12-inch | 97 | 97 | 425 | 50 | Artesian | | | Irrigation | †14 |
| 586 | Los Angeles County | do | H-15 | | Bored, 6-inch | 97 | 93 | 10 | 50 | Wind | $20.00 | $125.00 | Roads | |
| 587 | L. Sentons | Los Bueyes | H-15 | 1888? | Dug, 4 by 4 foot | 87 | 84 | 14 | 54 | do | | 75.00 | Domestic; stock | |
| 588 | do | do | H-15 | 1890? | do | 87 | 83 | 20 | | Steam | | | Factory | |
| 589 | Artesian Water Co | Paso de la Tijera | H-16 | 1902 | do | 98 | 89 | 16 | 73 | Wind | | | Domestic | |
| 590 | do | do | H-16 | | Dug, 3 by 4 foot | 100 | 96 | 12 | 129 | Hand | | | Domestic; stock | |
| 591 | Marius Monea | Los Bueyes | G-17 | 1901 | Bored, 8-inch | 190 | 155 | 225 | 77 | Wind | 300.00 | 100.00 | Domestic | |
| 592 | do | do | G-17 | | Dug, 4 by 4 foot | 190 | 155 | 38 | 77 | Hand | | | do | |
| 593 | W. B. Finch | do | G-16 | | Dug, 3 by 3 foot | 148 | 128 | 30 | 84 | do | | | do | |
| 594 | Lee Long | do | G-16 | | do | 175 | 171 | 8 | 62 | do | | | Domestic; irrigation. | |
| 595 | B. Casserini | do | G-16 | 1900 | Dug, 4 by 4 foot | 100 | 86 | 20 | 38 | Wind | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 596 | J. Vilelle | do | G-16 | 1901 | do | 96 | 68 | 35 | 72 | Hand | 50.00 | | Domestic | |
| 597 | A. D. Keating | do | G-16 | 1898 | Dug, 3 by 3 foot. | 88 | 58 | 35 | 61 | Wind | 50.00 | 75.00 | do | |
| 598 | do | La Ballona | G-16 | | do | 100 | 70 | 35 | 61 | do | 50.00 | 75.00 | do | |
| 599 | Mrs. C. O. Higuera | Los Bueyes | F-16 | 1897 | do | 102 | 66 | 40 | 81 | do | 60.00 | 100.00 | do | |
| 600 | E. R. Higuera | do | F-16 | 1901 | Dug | 102 | 66 | 40 | | | | | | |
| 601 | B. J. Higuera | do | F-16 | 1892 | Dug, 3 by 3 foot. | 103 | 65 | 50 | 74 | Wind | 65.00 | 100.00 | Domestic | |
| 602 | Mrs. Eliza Hoke | do | F-16 | 1903 | Bored, 10-inch | 103 | 68 | 70 | 79 | do | 115.50 | | do | |
| 603 | Mr. Bottler | do | G-16 | | Dug, 3 by 3 foot. | 104 | 85 | 23 | 43 | Hand | | | do | |
| 604 | Mrs. R. Krueger | do | G-16 | 1901 | do | 104 | 86 | 24 | 118 | Wind | 30.00 | 100.00 | do | |
| 605 | L. V. Higuera | do | G-16 | 1899 | Dug, 3 by 4 foot. | 104 | 84 | 29 | 85 | do | | | do | |
| 606 | Los Angeles County | do | G-16 | 1901 | Bored, 7-inch | 102 | 90 | 47 | 77 | do | | | Roads; stock | |
| 607 | L. V. Higuera | do | G-16 | 1887 | Dug, 4 by 4 foot. | 104 | 88 | 36 | 79 | do | 50.00 | 100.00 | Domestic | |
| 608 | A. D. Keating | do | G-16 | 1899 | do | 94 | 92 | 10 | 57 | Hand | 25.00 | | do | |
| 609 | C. E. Hodgson | Sec. 9, T. 1 S., R. 14 W. | I-11 | 1894 | Bored, 7-inch | 320 | 260 | 284 | 56 | Gas, wind | 494.00 | 500.00 | Irrigation; domestic. | |
| 610 | S. Moran | do | I-11 | 1894 | Dug, 2½ by 2½ foot. | 300 | Dry. | 60 | | | | | | |
| 611 | A. K. Rawson | do | I-11 | 1902 | Bored, 7-inch | 300 | 213 | 208 | 50 | Gas | 283.00 | 200.00 | Irrigation | |
| 612 | Mr. Plummer | do | I-11 | | do | 285 | 207 | 80 | 58 | Wind | | | Domestic | |
| 613 | W. J. Rooks | do | I-11 | 1901 | Dug, 3½-foot diameter. | 270 | 225 | 60 | 56 | do | 100.00 | 75.00 | do | |
| 614 | Alfred Watts | do | H-11 | | Bored, 10-inch | 300 | 199 | 300? | | Gas? | | | Irrigation | |
| 615 | K. C. Wagonbach | Sec. 16, T. 1 S., R. 14 W. | H-11 | | Dug, 4 by 4 foot. | 290 | 210 | 85 | 54 | Wind | | | Domestic | |
| 616 | School district | Sec. 17, T. 1 S., R. 14 W. | H-11 | | Bored, 7-inch | 295 | 208 | 102 | 53 | do | 120.00 | 125.00 | do | |
| 617 | I. N. Wilson | Sec. 9, T. 1 S., R. 14 W | H-11 | 1895 | do | 350 | 235 | 385 | 49 | Electric motor | 750.00 | 350.00 | Irrigation | †9 |
| 618 | H. C. Bradley | do | I-11 | | do | 400 | 230 | 250 | | Gas | | | do | |
| 619 | I. N. Large | do | H-11 | 1900 | Dug, 4 by 4 foot. | 475 | 430 | 95 | 45 | do | | | Domestic; irrigation. | †4 |
| 620 | W. J. Bliesner | do | H-11 | 1902 | Bored, 7-inch | 475 | 435 | 290 | 56 | do | *1,800.00 | | do | |
| 621 | J. Miller | do | H-11 | 1897 | Dug, 4 by 4 foot. | 500 | | 40 | | do | 75.00 | 200.00 | Domestic | |
| 622 | Wm. Wagonbach | Sec. 17, T. 1 S., R. 14 W. | H-11 | 1897 | do | 290 | 210 | 84 | 54 | Wind | 100.00 | 125.00 | do | |
| 623 | Mrs. A. Hay | Sec. 8, T. 1 S., R. 14 W. | H-11 | 1883 | Bored, 7-inch | 320 | 205 | 120 | 62 | do | | | Domestic; irrigation. | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 624 | A. C. Watts | La Brea | H-11 | 1893 | Bored, 7-inch | 290 | 210 | 170 | 65 | Gas | $235.00 | $750.00 | Irrigation; domestic. | †6 |
| 625 | Jno. B. Schock | do | H-11 | 1893 | do | 330 | 211 | 150 | 65 | Wind | 170.00 | 169.00 | Domestic | |
| 626 | Henry Ludwig | Sec. 8, T. 1 S., R. 14 W. | G-11 | 1895 | Dug, 3 foot diameter. | 400 | 334 | 70 | 40 | do | | 125.00 | do | |
| 627 | Helen Moore | do | G-11 | 1895 | Dug, 4 by 4 foot. | 350 | 290 | 80 | 40 | do | 100.00 | 125.00 | do | |
| 629 | L. A. P. Rwy. Co | La Brea | G-12 | 1897 | Bored, 12-inch | 215 | 215 | 480 | 133 | Compressed air | | | Boiler | |
| 630 | Judge Stephens | do | H-30 | | Dug, 3 foot diameter. | 250 | Dry. | 35 | | | 60.00 | | | |
| 631 | A. G. Randall | do | G-11 | 1902 | Bored, 19-inch | 320 | 280 | 195 | | Wind | 200.00 | 150.00 | Domestic | |
| 632 | Tom Quint | do | G-11 | 1902 | Bored, 6-inch | 330 | 330 | 185 | 58 | Artesian | | | do | |
| 633 | Quint & Durfee | do | G-11 | 1897 | Bored | 320 | 320 | | 58 | do | | | do | |
| 634 | Bristol Sisters | Sec. 7, T. 1 S., R. 14 W. | G-11 | 1891 | Dug, 5 foot diameter. | 400 | 312 | 91 | 35 | Wind | | | do | |
| 635 | Mrs. L. J. Dunkle | Sec. 18, T. 1 S., R. 14 W. | G-11, 12 | | Dug, 3 foot diameter. | 340 | 318 | 30 | 29 | do | 50.00 | 150.00 | do | |
| 636 | Mrs. F. Swall | Rodeo de las Aguas. | G-12 | 1889 | Bored, 7-inch | 290 | 274 | 140 | 35 | do | 150.00 | 65.00 | do | |
| 637 | J. A. Swall | do | G-12 | 1900 | Hydraulic, 3-inch. | 205 | 205 | 500 | 59 | Artesian | 400.00 | | Irrigation | 5 |
| 638 | do | do | G-12 | 1900 | Hydraulic, 4-inch. | 187 | 182 | 960 | | | 1,000.00 | | Not used | |
| 639 | do | do | G-12 | 1898 | Bored, 7-inch | 200 | 195 | 300 | 59 | Gas | 400.00 | 600.00 | Irrigation | |
| 640 | do | do | G-12 | 1901 | Bored, 12-inch | 210 | 204 | 300 | | | 700.00 | | Not used | |
| 641 | L. T. Swall | do | G-12 | 1889 | Bored, 7-inch | 211 | 193 | 32 | | Wind | 50.00 | 65.00 | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 642 | ....do | ....do | G-12 | 1900 | ....do | 200 | 200 | 75 | | Gas, artesian | 75.00 | 900.00 | Irrigation | |
| 643 | ....do | ....do | G-12 | 1899 | Bored, 10-inch; bored, 6-inch. | 200 | 200 | 150 | | Artesian, gas | 120.00 | | ....do | |
| 644 | ....do | ....do | G-12 | 1900 | Bored, 7-inch | 200 | 200 | 150 | 59 | Gas | 170.00 | | ....do | |
| 645 | Chas. Picot | ....do | G-13 | 1887 | ....do | 188 | 165 | 100 | 61 | Wind | 100.00 | 100.00 | Domestic | |
| 646 | Hommel & Deuker | ....do | G-13 | 1899 | Bored, 12-inch | 191 | 152 | 200 | 46 | ....do | 300.00 | 125.00 | Stock | |
| 647 | ....do | ....do | F-12 | 1902 | Hydraulic, 4-inch. | 262 | 207 | 202 | | ....do | | | Domestic; stock | |
| 648 | ....do | ....do | G-13 | 1878 | Bored, 7-inch | 169 | 155 | 150 | 63 | ....do | 170.00 | 125.00 | ....do | |
| 649 | ....do | ....do | G-13 | 1883 | ....do | 169 | 161 | 200 | 59 | Hand | 225.00 | | Stock | |
| 650 | ....do | ....do | F-13 | 1902 | Bored, 12-inch | 200 | 153 | 200 | | Wind | 235.00 | 125.00 | ....do | |
| 651 | Conception Alvares | Sec. 18, T. 1 S., R. 14 W. | G-11 | 1895 | Dug, 3 by 3 foot. | 400 | 361 | 42 | 49 | Hand | | | Domestic | |
| 652 | E. Harrott | ....do | G-11 | 1902 | Bored, 7-inch | 400 | 366 | 155 | 42 | Wind | 175.00 | 125.00 | ....do | |
| 653 | P. T. Durfee | Sec. 12, T. 1 S., R. 15 W. | F-11 | | Bored | 550 | 480 | 700 | | | | | | |
| 654 | M. S. Yager | ....do | F-11 | | Dug | 510 | | 17 | 48 | Tunnel | | | Irrigation | (a) |
| 655 | School district | Rodeo de las Aguas | E-12 | | Bored, 7-inch | 410 | 339 | 112 | 54 | Hand | 125.00 | | Domestic | |
| 656 | Hommel & Deuker | ....do | E-12 | | ....do | 410 | | | | | | | Not used | |
| 657 | ....do | ....do | F-12 | | Hydraulic, 4-inch. | 425 | | 480 | | | | | | |
| 658 | Robert Whitworth | ....do | G-14 | 1890 | Bored, 7-inch | 150 | 104 | 119 | 61 | Wind | 125.00 | 100.00 | Domestic | |
| 659 | L. Bertramo | Los Bueyes | F-14 | | ....do | 200 | 131 | 100 | 44 | ....do | 100.00 | 75.00 | ....do | |
| 660 | G. Espelet | Rodeo de las Aguas. | G-14 | | Dug, 3 by 4 foot. | 160 | 100 | 75 | 74 | ....do | 100.00 | 75.00 | ....do | |
| 661 | Jose Sesma | Los Bueyes | G-15 | 1893 | Bored, 7-inch | 160 | 122 | 50 | 79 | ....do | 75.00 | 65.00 | ....do | |
| 662 | M. Arnez | ....do | G-15 | | ....do | 170 | 105 | 70 | 80 | ....do | 75.00 | 75.00 | ....do | |
| 663 | J. Ordoque | ....do | G-15 | | ....do | 175 | 101 | 90 | 61 | ....do | 100.00 | 65.00 | ....do | |
| 664 | Jose Sesma | ....do | G-15 | | Dug, 4 by 4 foot. | 125 | 97 | 32 | 76 | Hand | 50.00 | | ....do | |
| 665 | Ygnacio Valenzuela | ....do | G-15 | | Dug, 3 by 3 foot. | 125 | 100 | 26 | 79 | ....do | 35.00 | | ....do | |
| 666 | E. Sanz | ....do | G-15 | 1890 | ....do | 125 | 101 | 26 | 72 | ....do | | | ....do | |
| 667 | ....do | ....do | G-15 | 1891 | Bored, 7-inch | 125 | 100 | 50 | 70 | Wind | | | ....do | |
| 668 | Antonio R. Rocha | ....do | G-15 | | Dug, 3 by 3 foot. | 125 | 101 | 26 | 67 | Hand | | | ....do | |
| 669 | M. Royner | ....do | G-15 | | Bored, 7-inch | 120 | 93 | 31 | 71 | Wind | 40.00 | 65.00 | ....do | |
| 670 | A. J. Rocha | ....do | G-15 | 1888 | ....do | 120 | 90 | 36 | 66 | ....do | 50.00 | 75.00 | ....do | |

a Small.

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 671 | Jean Seutons | Los Bueyes | G-15 | | Bored, 7-inch | 140 | 73 | 77 | 73 | Wind | $100.00 | $65.00 | Domestic | |
| 672 | Jean Bourbel | do | F-15 | | Dug, 3 by 3 foot | 140 | 75 | 70 | 68 | do | 65.00 | | do | |
| 673 | A. D. Keating | do | F-15 | | do | 140 | 75 | 70 | 73 | do | 75.00 | | Stock | |
| 674 | D. M. Vejar | do | G-16 | 1900 | Bored, 7-inch | 109 | 89 | 28 | 103 | do | 50.00 | 75.00 | Domestic | |
| 675 | L. Seutons | do | F-16 | 1885? | do | 138 | 90 | 52 | 160 | do | 65.00 | 125.00 | Irrigation | |
| 676 | Joe Lamb | do | F-15 | 1885 | do | 170 | 76 | 109 | 67 | do | 125.00 | 100.00 | Domestic | |
| 677 | Byron Clark | do | F-16 | 1889 | Dug, 4 by 4 foot | 145 | 95 | 55 | | do | | 100.00 | Domestic; irrigation. | |
| 678 | Garnsey Investment Co. | do | F-16 | 1896 | Dug, 4 by 6 foot | 150 | 101 | 75 | 64 | Gas | 300.00 | 1,100.00 | Irrigation | †7 |
| 679 | do | do | F-15 | 1893 | Bored, 7-inch | 242 | 62 | 234 | 62 | Wind | 325.00 | 250.00 | Domestic | |
| 680 | Hommel & Deuker | Rodeo de las Aguas. | E-13 | 1899 | do | 290 | 226 | 200 | 85 | Hand | 250.00 | | Stock | |
| 681 | do | do | E-13 | | Dug, 6 by 6 foot | 290 | Dry. | 50 | | | | | | |
| 682 | do | do | E-13 | | Bored, 7-inch | 300 | 234 | 75 | | | | | Not used | |
| 683 | J. W. Wolfskill | Buenos Ayres | E-14 | 1903 | Dug, 3-foot diameter. | 245 | 245 | 4 | 52 | Hand | | | Domestic; stock | |
| 684 | Francisco Sabichi | La Ballona | E-15 | 1899 | Bored, 7-inch | 175 | 41 | 137 | 37 | Wind | 150.00 | 100.00 | Domestic | |
| 685 | E. R. Taylor | do | E-15 | 1903 | Bored, 8-inch | 180 | 60 | 145 | 54 | do | 211.00 | 100.00 | do | |
| 686 | C. W. Comstock | do | E-15 | | Bored, 4-inch | 170 | 55 | 135 | 50 | do | | 150.00 | do | |
| 687 | C. A. Freeman | do | E-15 | 1888 | Bored, 7-inch | 180 | 55 | 150 | 50 | do | 150.00 | | do | |
| 688 | do | do | E-15 | 1888 | do | 180 | 55 | 150 | 50 | | 150.00 | | Not used | |
| 689 | do | do | E-15 | 1888 | do | 180 | 55 | 150 | 50 | | 150.00 | | do | |
| 690 | Geo. Lynn | do | E-15 | | Bored | 187 | | | 47 | Wind, gas | | 300.00 | Domestic | |
| 691 | Mrs. C. Griffin | do | E-15 | | Bored, 7-inch | 205 | 54 | 169 | | Wind | 200.00 | 125.00 | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 692 | J. S. Lowe | do | E-16 | 1902 | Bored, 8-inch | 204 | 54 | 300 | 61 | Gas | 2,000.00 | 250.00 | do | |
| 693 | W. K. Church | do | E-16 | | Bored, 10-inch | 201 | 54 | 305 | 56 | Wind, gas | 335.00 | 300.00 | Domestic; irrigation. | |
| 694 | Mr. Driggs | do | E-16 | | Bored, 7-inch | 163 | 71 | 200 | 81 | Gas | | | Irrigation | |
| 695 | do | do | E-16 | | do | 165 | 55 | 200 | 81 | Wind | 240.00 | 125.00 | Domestic | |
| 696 | L. M. Kapp | do | E-16 | 1893 | do | 165 | 70 | 250 | 55 | do | 300.00 | 125.00 | do | |
| 697 | Mrs. A. Nast | do | E-15 | | Bored | 225 | 68 | 300 | 59 | Gas | | | Irrigation | |
| 698 | Mrs. Nast | do | E-15 | | Bored, 7-inch | 225 | 68 | 240 | 59 | Wind | | | Irrigation; domestic. | |
| 699 | A. L. King | Las Bueyes | E-15 | 1899 | do | 230 | 70 | 240 | 66 | do | 300.00 | | | |
| 700 | A. F. Gilmore | do | F-15 | | do | 285 | 105 | 200+ | 52 | do | | 150.00 | Stock | |
| 701 | do | do | F-14 | | do | 200 | 97 | 105 | | do | 125.00 | 100.00 | do | |
| 702 | Mrs. E. Hughes | Buenos Ayres | D-14 | 1891 | Bored, 4-inch | 320 | 248 | 145 | 63 | do | 150.00 | 125.00 | Domestic | |
| 703 | M. A. Wolfskill | do | D-14 | | Dug, 8 by 8 foot | 270 | 264 | 12 | 36 | do | | 100.00 | Domestic; stock | |
| 704 | Pacific Land Co | Santa Monica | C-14 | 1902 | Bored, 12-inch | 255 | 212 | 550 | 79 | Gas | 1,000.00 | | Domestic | †20 |
| 705 | do | do | C-14 | 1899 | do | 255 | 210 | | | | | | Not used | |
| 706 | do | do | C-14 | | Bored, 10-inch | 255 | 210 | 140 | 79 | | | | do | |
| 707 | do | do | C-14 | | do | 255 | 210 | | 79 | | | | do | |
| 708 | Peter Hayes | do | C-14 | 1902 | Dug, 3 by 3 foot | 255 | 206 | 52 | 72 | Wind | 72.00 | 200.00 | Domestic | |
| 709 | Mrs. C. C. Willey | do | C-14 | 1902 | Dug | 238 | 170 | 70 | 66 | do | 30.00 | 150.00 | do | |
| 710 | Frank Langdon | do | D-15 | 1900 | Dug, 4 by 4 foot, 73 feet; bored, 7-inch, 47 feet. | 228 | 161 | 120 | 67 | do | | 200.00 | do | |
| 711 | J. R. Fish | do | D-15 | 1903 | Bored, 7-inch | 208 | 142 | 125 | 56 | do | 150.00 | 100.00 | do | |
| 712 | C. M. L. Hill | do | D-15 | 1902 | Dug, 4 by 4 foot, 100 feet; bored, 7-inch, 103 feet. | 198 | 73 | 203 | | do | 329.00 | 125.00 | do | |
| 713 | E. J. Calhoun | do | D-15 | 1903 | Dug, 3 by 3 foot | 193 | 122 | 73 | 63 | Hand | 75.00 | | do | |
| 714 | O. E. Buffuns | do | D-15 | 1903 | Bored, 7-inch | 193 | 122 | 76 | 69 | Wind | 76.00 | 50.00 | do | |
| 715 | Chris. Lundy | do | D-15 | 1902 | do | 188 | 125 | 219 | 66 | do | 342.50 | 150.00 | do | |
| 716 | Mr. Bopes | do | D-15 | | do | 173 | 90 | 127 | | Gas | 150.00 | 450.00 | Domestic; irrigation. | |
| 717 | Barnard and Oreb | La Ballona | D-15 | 1902 | Bored | 160 | 80 | 200 | 78 | do | | | Irrigation | 40 |
| 718 | do | do | D-15 | 1883 | Bored, 7-inch | 160 | 90 | 250 | 78 | Wind | 300.00 | | Domestic | |
| 719 | S. Walters | do | D-15 | 1898 | do | 159 | 33 | 209 | 72 | do | 265.00 | 100.00 | do | |
| 720 | W. M. Pitman | Santa Monica | D-15 | 1902 | Dug, 3 by 3 foot. | 196 | 132 | 68 | 66 | do | 119.00 | 150.00 | do | |
| 721 | Robert Mandell | do | D-15 | 1901 | do | 197 | 124 | 75 | | do | 85.00 | 175.00 | do | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 722 | Mrs. L. E. Allen | Santa Monica | D-15 | 1901 | Dug, 3 by 3 foot. | 203 | 125 | 85 | 68 | Wind | | | Domestic | |
| 723 | E. E. Delano | do | D-15 | 1901 | Bored, 7-inch | 204 | 134 | 110 | 70 | do | $125.00 | $175.00 | do | |
| 724 | W. H. Tucker | do | C-15 | 1901 | Dug, 3 by 3 foot. | 225 | 153 | 74 | 73 | do | 100.00 | 100.00 | do | |
| 725 | Thomas F. Henry | do | C-15 | 1902 | Bored, 7-inch | 234 | 164 | 125 | 77 | do | 162.00 | 100.00 | do | |
| 726 | H. K. Laird | do | C-14 | 1899 | Dug, 3½ by 3½ foot. | 247 | 187 | 70 | 76 | do | 70.00 | 275.00 | do | |
| 727 | W. R. Chapman | do | C-15 | 1902 | do | 237 | 175 | 65 | 69 | do | 100.00 | 250.00 | Domestic; irrigation. | |
| 728 | E. G. Woodward | do | C-15 | 1900 | Dug, 3 by 3 foot. | 227 | 163 | 68 | 75 | do | 100.00 | 250.00 | Domestic | |
| 729 | E. S. West | do | C-15 | 1900 | Dug, 4 by 4 foot. | 226 | 164 | 65 | 77 | do | 100.00 | 225.00 | do | |
| 730 | Mr. Bright | do | C-15 | 1900 | Dug, 3 by 3 foot. | 225 | 163 | 65 | 78 | do | 100.00 | 150.00 | do | |
| 731 | Mathew Stewart | do | C-15 | 1901 | do | 224 | 157 | 72 | 77 | do | 100.00 | 175.00 | do | |
| 732 | J. W. Taylor | do | C-15 | 1901 | do | 223 | 159 | 76 | 80 | do | 100.00 | 65.00 | Domestic; irrigation. | |
| 733 | Chas. Howard | do | C-15 | 1900 | do | 220 | 153 | 70 | 76 | do | 100.00 | 65.00 | Domestic | |
| 734 | A. Wiseman | do | C-15 | 1902 | Dug, 3 by 3 foot, 76 feet; bored, 7-inch, 18 feet. | 220 | 150 | 94 | 75 | Gas | 125.00 | 225.00 | Irrigation | |
| 735 | do | do | C-15 | 1901 | Dug, 3½ by 3½ foot. | 218 | 150 | 70 | 75 | Wind | 100.00 | | Domestic | |
| 736 | J. S. Wiseman | do | C-15 | 1901 | do | 220 | 136 | 86 | 75 | do | 100.00 | 65.00 | do | |
| 737 | O. E. Roberts | do | D-15 | 1902 | Bored, 8-inch | 194 | 122 | 130 | 71 | Gas | 180.00 | 700.00 | Irrigation; domestic. | |
| 738 | E. H. Thornbrue | do | D-15 | 1902 | Dug, 4 by 4 foot. | 184 | 104 | 82 | 75 | Hand | 120.00 | | Domestic | |
| 739 | D. L. Allen | do | D-15 | 1902 | Bored, 8-inch | 179 | 89 | 160 | 78 | Gas | 224.00 | 550.00 | Irrigation | 9 |
| 740 | D. D. Dooley | do | D-15 | 1902 | Bored, 7-inch | 171 | 95 | 145 | | do | 188.00 | 200.00 | Domestic; irrigation. | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 741 | Mr. Latour | do | D-15 | 1902 | Dug, 4 by 4 foot. | 166 | 91 | 80 | 80 | Wind | 125.00 | 100.00 | Domestic | |
| 742 | Mr. Hanson | do | C-15 | 1902 | Dug, 3 by 3 foot. | 167 | 99 | 73 | 82 | do | 100.00 | 250.00 | do | |
| 743 | A. N. King | do | D-15 | 1902 | Bored, 7-inch | 174 | 99 | 150 | 77 | do | 200.00 | 60.00 | do | |
| 744 | P. W. Mallory | do | D-15 | 1903 | Dug, 3 by 3 foot. | 186 | 102 | 87 | 81 | do | 120.00 | 350.00 | do | |
| 745 | John Barratt | do | C-15 | 1902 | Dug, 3½ by 3½ foot. | 191 | 111 | 83 | 76 | do | | | do | |
| 746 | Richard Felch | do | C-15 | 1902 | Dug, 3 by 3 foot. | 191 | 105 | 90 | 78 | do | 125.00 | 75.00 | do | |
| 747 | D. Kennedy | do | C-15 | 1901 | do | 193 | 111 | 86 | 81 | do | 125.00 | 75.00 | do | |
| 748 | Mr. Majors | do | C-15 | 1902 | Dug, 4 by 4 foot. | 209 | 141 | 73 | 80 | do | 100.00 | 65.00 | Irrigation | |
| 749 | C. J. Ekhalin | do | C-15 | 1902 | Dug, 3 by 3 foot. | 210 | 147 | 65 | 74 | do | 100.00 | 75.00 | Domestic | |
| 750 | Dan Shibely | do | C-15 | 1901 | Dug, 3½ by 3½ foot. | 222 | 161 | 65 | 73 | do | 90.00 | 125.00 | do | |
| 751 | J. W. Belote | do | C-15 | 1901 | Bored, 7-inch | 200 | 126 | 90 | 81 | do | 112.50 | 75.00 | do | |
| 752 | J. B. Mallory | do | C-15 | 1902 | Dug, 3½ by 3½ foot. | 185 | 107 | 83 | 78 | do | 75.00 | 100.00 | do | |
| 753 | Geo. W. Lacell | do | C-15 | 1902 | Dug, 3 by 3 foot. | 177 | 104 | 76 | 83 | do | 90.00 | 200.00 | Domestic; irrigation. | |
| 754 | J. Murray | do | C-15 | 1902 | do | 173 | 105 | 74 | 80 | do | | | Domestic | |
| 755 | C. M. Farr | do | C-15 | 1902 | do | 177 | 104 | 78 | 82 | do | 125.00 | 100.00 | do | |
| 756 | J. C. Charles | do | C-15 | 1901 | Bored, 7-inch | 199 | 129 | 103 | 80 | do | 125.00 | 70.00 | do | |
| 757 | L. P. Heldman | do | C-15 | 1901 | Dug, 4 by 4 foot. | 203 | 124 | 83 | 80 | do | 100.00 | 65.00 | do | |
| 758 | D. Valdez | do | C-15 | 1902 | Dug, 3 by 3 foot. | 182 | 118 | 74 | 78 | do | 100.00 | 65.00 | do | |
| 759 | Mr. White | do | C-15 | 1902 | Bored, 16-inch | 177 | 105 | 80 | 85 | Hand | 80.00 | | do | |
| 760 | Mrs. B. P. Diehl | do | C-15 | 1903 | Bored, 8-inch | 170 | 113 | 100 | 85 | Wind | 125.00 | 200.00 | do | |
| 761 | J. L. Edwards | do | C-15 | 1902 | Dug, 3 by 3 foot. | 177 | 119 | 68 | 68 | do | 100.00 | 200.00 | do | |
| 762 | John Charles | do | C-15 | 1902 | Bored, 7-inch | 181 | 121 | 106 | 84 | do | 80.00 | 144.00 | do | |
| 763 | J. K. Thomas | do | C-15 | 1903 | Dug, 3 by 3 foot, 84 feet; bored, 12-inch, 120 feet. | 185 | 121 | 204 | 82 | do | 330.00 | 350.00 | Domestic; irrigation. | |
| 764 | M. E. Robbins | do | C-15 | 1903 | Dug, 3 by 3 foot. | 185 | 106 | 83 | 85 | do | 100.00 | 133.00 | Domestic | |
| 765 | H. M. Smith | do | C-15 | 1902 | do | 197 | 117 | 87 | 61 | do | 87.00 | 150.00 | Domestic; irrigation. | |
| 766 | Chas. Fanetti | do | C-15 | 1901 | do | 189 | 124 | 70 | 80 | Hand | 100.00 | | Domestic | |
| 767 | Jasper Thomason | do | B-15 | 1902 | Bored, 12-inch | 186 | 110 | 300 | 67 | Gas | 675.00 | 715.00 | Irrigation; domestic. | 12 |
| 768 | do | do | B-15 | 1900 | Bored, 7-inch | 179 | 99 | 120 | 67 | Wind | 150.00 | 100.00 | Domestic; irrigation. | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 769 | Jasper Thomason | Santa Monica | B-15 | | Bored, 7-inch | 179 | 99 | 120 | 67 | Wind | $135.00 | $100.00 | Domestic; irrigation. | |
| 770 | Carpenter & Dexter | do | B-15 | 1900 | Bored, 10-inch | 187 | 122 | 272 | 58 | Gas | | 1,500.00 | Irrigation | 10 |
| 771 | do | do | B-15 | 1897 | do | 184 | 116 | 80 | 70 | Wind | 100.00 | 175.00 | do | |
| 772 | Mrs. L. H. Hubbel | do | B-16 | | | 160 | 100 | 100? | 63 | do | | 65.00 | Domestic | |
| 773 | Chas. Jenkins | do | B-15 | 1903 | Bored, 7-inch | 175 | 110 | 119 | 58 | do | 150.00 | 150.00 | do | |
| 775 | N. R. Brown | La Ballona | C-16 | | do | 148 | 59 | 104 | 75 | do | 100.00 | 65.00 | Domestic; stock | |
| 776 | A. L. Whittaker | do | C-16 | 1899 | Bored, 8-inch | 190 | 63 | 315 | 81 | do | 600.00 | 250.00 | Domestic | |
| 777 | do | do | C-16 | | Bored, 7-inch | 190 | 63 | 130 | | Not used | | | | |
| 778 | Jonathan Tibbets | do | D-16 | 1880 | do | 137 | 44 | 98 | 73 | Wind | 100.00 | | Domestic | |
| 779 | L. C. Brown | do | D-16 | | do | 137 | 59 | 86 | 74 | do | 100.00 | 125.00 | do | |
| 780 | Tom Attrill | do | D-16 | 1902 | do | 138 | 44 | 126 | 74 | do | 135.00 | 65.00 | do | |
| 781 | R. D. Pontius | do | D-16 | 1900 | do | 138 | 48 | 200 | | Gas | 300.00 | 300.00 | Domestic; irrigation. | 4 |
| 782 | Alonzo C. Smith | do | E-16 | | Dug, 3 by 3 foot. | 138 | Dry. | 78 | | | | | | |
| 783 | do | do | E-16 | | Bored, 7-inch | 138 | 40 | 106 | 76 | Wind | 125.00 | 65.00 | Domestic; stock | |
| 784 | C. Wicks | do | D-15 | 1903 | Bored, 12-inch | 149 | 59 | 319 | 58 | Gas | 660.00 | 1,075.00 | Domestic; irrigation. | 15 |
| 785 | Alonzo C. Smith | do | D-15 | | Bored, 7-inch | 159 | Dry. | 87 | | | 100.00 | | | |
| 786 | A. Beal | do | F-16 | 1896 | Dug, 3 by 3 foot. | 141 | 105 | 36 | 57 | Hand | 50.00 | | Domestic | |
| 787 | do | Los Bueyes | F-16 | 1896 | Dug, 4½ by 6 foot | 130 | 88 | 103 | 59 | Gas | 500.00 | 700.00 | Irrigation | |
| 788 | E. Kubis | La Ballona | F-16 | 1902 | Dug, 3 by 3 foot. | 135 | 98 | 42 | 65 | do | 60.00 | 225.00 | Domestic; irrigation. | †3 |
| 789 | Y. Nishi | do | F-16 | 1899 | Bored, 7-inch | 128 | 98 | 76 | 68 | Wind | 75.00 | 75.00 | Domestic | |
| 790 | Mrs. E. L. Highley | do | F-16 | 1895 | Dug, 3-foot diameter. | 122 | 90 | 37 | 65 | do | 75.00 | 65.00 | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 791 | Newmark & Edwards | do | D-16 | 1894 | Bored, 7-inch | 128 | 52 | 94 | 77 | do | 100.00 | 75.00 | Domestic; stock | |
| 792 | M. Stevens | do | D-16 | 1894 | do | 120 | 48 | 82 | 89 | do | 80.00 | 65.00 | Domestic | |
| 793 | Jacob Brown | do | D-16 | 1897 | Dug, 3 by 3 foot, 60 feet; bored, 4-inch, 140 feet. | 118 | 56 | 200 | 71 | do | 350.00 | 100.00 | do | |
| 794 | Newmark & Edwards | do | D-16 | | Bored, 7-inch | 118 | 47 | 72 | | do | 75.00 | 65.00 | do | |
| 795 | L. Lorbeer | do | E-16 | 1884 | do | 120 | 53 | 87 | 59 | do | 90.00 | 95.00 | do | |
| 796 | N. P. Cole | do | E-17 | 1884 | do | 118 | 58 | 88 | 55 | do | 110.00 | 150.00 | Domestic; stock | |
| 797 | Arnold Schaub | do | E-16 | | do | 138 | 54 | 130 | 53 | do | 150.00 | 65.00 | Domestic | |
| 798 | D. S. Bryant | do | E-16 | 1898 | do | 130 | 65 | 105 | 39 | do | 125.00 | 65.00 | do | |
| 799 | C. Valdez | do | E-16 | 1889 | Dug, 3 by 3 foot. | 145 | 48 | 100 | 65 | do | 100.00 | 125.00 | do | |
| 800 | Andres Ybarra | do | E-16 | 1901 | do | 105 | 63 | 46 | 40 | Hand | 50.00 | | do | |
| 801 | John Lestelle | do | E-16 | 1902 | do | 105 | 63 | 47 | 39 | do | | | do | |
| 802 | Jesus Saenz | do | E-16 | 1901 | do | 148 | 47 | 102 | 80 | do | 100.00 | | do | |
| 803 | John Skillman | do | E-16 | 1902 | Bored, 8-inch | 145 | 50 | 180 | 29 | Wind | 280.00 | 75.00 | do | |
| 804 | James McKee | do | E-16 | 1902 | Dug, 3½ by 3½ foot. | 150 | 94 | 59 | 102 | do | 60.00 | 50.00 | do | |
| 805 | J. S. Lowe | do | E-16 | | Bored, 7-inch | 175 | 96 | 106 | 68 | do | 125.00 | 65.00 | do | |
| 806 | C. A. Winship | do | F-16 | 1886 | Dug, 6 by 4 foot. | 137 | 107 | 45 | | Gas | | | do | |
| 807 | do | do | F-16 | 1886 | Dug, 4 by 6 foot. | 137 | 107 | 45 | | do | | | do | |
| 808 | G. P. Shanks | do | F-16 | 1896 | Dug, 3½ by 3½ foot. | 135 | 107 | 40 | 72 | Wind | 40.00 | 65.00 | do | |
| 809 | I. Fellows | do | F-16 | 1893 | Dug, 4 by 4 foot. | 134 | 107 | 37 | 133 | do | 40.00 | 100.00 | do | |
| 810 | John Coyner | do | F-16 | | Dug, 3½ foot diameter. | 108 | 78 | 37 | 60 | do | 50.00 | 50.00 | do | |
| 811 | W. R. Scurlock | do | F-16 | 1893 | Bored, 7-inch | 104 | 77 | 72 | 60 | do | 75.00 | 100.00 | do | |
| 812 | Palms Catholic Church | do | F-16 | 1898 | Dug, 4 by 4 foot. | 99 | 74 | 27 | 58 | do | 30.00 | 65.00 | do | |
| 813 | Los Angeles Co | do | F-16 | | Bored, 7-inch | 95 | 72 | 98 | 56 | do | 100.00 | 125.00 | Roads | |
| 814 | Geo. Charnock | do | E-16 | 1889 | do | 121 | 65 | 80 | 88 | do | 80.00 | 150.00 | Domestic | |
| 815 | John Monlon | do | E-16 | 1901 | Dug, 3 by 3 foot. | 126 | 80 | 50 | 69 | do | 50.00 | 65.00 | do | |
| 816 | Martin Brown | do | E-16 | | Bored, 7-inch | 136 | 93 | 60 | 85 | do | 75.00 | 100.00 | do | |
| 817 | Mrs. L. J. DePee | do | E-16 | 1902 | do | 125 | 74 | 176 | 60 | do | 225.00 | 100.00 | do | |
| 818 | Ed Bryant | do | E-16 | 1901 | Dug, 4 by 4 foot. | 130 | 70 | 80 | 73 | Hand | 80.00 | | do | |
| 819 | D. Moriarty | do | F-16 | 1899 | Dug, 3 by 3 foot. | 125 | 75 | 63 | 82 | Wind | *250.00 | | do | |
| 820 | M. F. Kane | do | F-16 | 1901 | Bored, 7-inch | 125 | 74 | 250? | 65 | do | *500.00 | | do | |
| 821 | J. P. Ward | do | F-16 | | do | 130 | 72 | 75 | 61 | do | 75.00 | 75.00 | do | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 822 | F. E. Schuedig | La Ballona | F-16 | 1902 | Dug, 4 foot diameter. | 123 | 74 | 54 | 47 | Gas | $150.00 | $250.00 | Domestic | |
| 823 | Robert Lowe | do | F-16 | 1889 | Dug, 4 by 4 foot. | 120 | 79 | 45 | 42 | Wind | 45.00 | 65.00 | do | |
| 824 | W. W. LaForge | do | F-16 | 1901 | Dug, 3½ by 3½ foot. | 117 | 80 | 42 | 58 | do | | | do | |
| 825 | Calvin Ford | do | F-16 | 1901 | Dug | 115 | 78 | 45 | 44 | Hand | 50.00 | | do | |
| 826 | G. Kidson | do | F-16 | 1888 | Bored, 7-inch | 109 | 86 | 48 | 103 | Wind | | | do | |
| 827 | Chas. Ford | do | F-16 | 1902 | do | 116 | 85 | 52 | 15 | do | | 65.00 | do | |
| 828 | United Brethren Church. | do | F-16 | | Dug, 4 by 4 foot. | 120 | 78 | 46 | 45 | do | 50.00 | 100.00 | do | |
| 829 | F. P. Bojorquez | do | E-16 | | do | 118 | 74 | 50 | 65 | do | 50.00 | 100.00 | do | |
| 830 | L. McDonnell | do | F-16 | 1899 | Bored, 7-inch | 110 | 77 | 77 | 35 | do | 80.00 | 50.00 | do | |
| 831 | L. Machado | do | E, F-16 | 1880 | do | 110 | 83 | 42 | 20 | do | 50.00 | 75.00 | do | |
| 832 | J. J. Chapman | do | F-16 | | do | 110 | 28 | 95 | 40 | do | 100.00 | 100.00 | do | |
| 833 | F. P. Bojorquez | do | F-16 | 1891 | do | 100 | 54 | 66 | 30 | do | 75.00 | 100.00 | do | |
| 834 | Jesus Saenz | do | F-16 | | Bored, 5-inch | 90 | 41 | 56 | 52 | do | 50,00 | 75.00 | do | |
| 835 | J. Illich Estate | do | F-16 | 1885 | Bored, 7-inch | 85 | 45 | 47 | 70 | do | 50.00 | 75.00 | do | |
| 836 | C. E. Stanton | do | D-17 | 1903 | Bored, 8¼-inch | 136 | 28 | 180 | 77 | do | 250.00 | 65.00 | do | |
| 837 | J. S. Cripe | do | D-17 | 1888 | Bored, 7-inch | 98 | 38 | 100 | 75 | Hand | | | do | |
| 838 | Jacob Brown | do | D-17 | 1900 | Dug, 3 by 3 foot. | 75 | 27 | 50 | 77 | do | | | do | |
| 839 | T. L. Gooch | do | D-17 | 1903 | Bored, 12-inch | 70 | 36 | 150 | 75 | Gas | 175.00 | 1,700.00 | Irrigation | 60 |
| 840 | H. McClelland | do | D-17 | 1903 | Bored, 7-inch | 74 | 29 | 62 | 75 | Hand | 60.00 | | Domestic | |
| 841 | Artesian Water Co. | do | D-17 | 1883 | do | 90 | 27 | 72 | 74 | Wind | 75.00 | 65.00 | Domestic; stock | |
| 842 | Henry Lowe | do | D-17 | 1884 | do | 97 | 27 | 110 | 77 | do | 100.00 | 75.00 | Domestic | |
| 843 | F. B. Koen | do | D-17 | 1888 | do | 87 | 28 | 105 | 67 | Gas | 100.00 | 200.00 | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 844 | E. Matlin | do | D, E-17 | 1887 | do | 98 | 37 | 90 | 55 | Wind | 90.00 | 75.00 | do | |
| 845 | Chas. Stinton | do | E-17 | | Bored, 6-inch | 100 | 47 | 62 | 36 | | | 70.00 | do | |
| 846 | W. T. McLaughlin | do | E-17 | 1900 | Bored, 7-inch | 110 | 45 | 106 | 61 | Wind | 125.00 | 75.00 | Domestic; irrigation. | |
| 847 | John McLaughlin | do | E-17 | 1903 | Dug, 4 by 8 foot, 40 feet; bored, 12-inch, 30 feet. | 75 | 35 | 70 | 58 | Gas | 225.00 | 1,250.00 | Irrigation | 50 |
| 848 | do | do | E-17 | 1886 | Bored, 7-inch | 67 | 42 | 55 | 73 | Wind | | | Domestic | |
| 849 | Los Angeles Co | do | E-17 | | do | 65 | 45 | 37 | | do | 50.00 | 125.00 | Roads | |
| 850 | John McDonald estate | do | E-17 | | do | 65 | 45 | 32 | 86 | do | 40.00 | 75.00 | Domestic | |
| 851 | J. B. Rentchler | do | E-17 | 1893 | Dug, 4 foot diameter. | 64 | 45 | 20 | 73 | do | 40.00 | 75.00 | do | |
| 852 | do | do | E-17 | | Dug, 3½ foot diameter. | 64 | 45 | 20 | 78 | Hand | 40.00 | | Stock | |
| 853 | John Reinhart | do | E-17 | | Bored, 7-inch | 75 | 40 | 37 | 53 | Wind | 50.00 | 75.00 | Domestic | |
| 854 | Mrs. S. M. Boyer | do | E-17 | | do | 70 | 40 | 44 | 47 | do | 50.00 | 65.00 | do | |
| 855 | do | do | E-17 | 1900 | do | 115 | 38 | 84 | | do | | 100.00 | do | |
| 856 | Mr. Horton | do | E-16 | 1895 | Dug, 65 feet; bored, 15 feet. | 120 | 50 | 80 | 38 | do | | 100.00 | do | |
| 857 | Ed Hall | do | F-16 | | Bored, 6-inch | 87 | 52 | 47 | | do | 50.00 | 75.00 | do | |
| 858 | G. Fea | do | F-17 | 1902 | Dug, 4 by 4 foot. | 63 | 36 | 31 | 64 | do | 35.00 | 100.00 | do | |
| 859 | B. Machado | do | F-17 | 1895 | do | 55 | 37 | 24 | 80 | do | 30.00 | 100.00 | do | |
| 860 | do | do | F-17 | 1873 | Dug, 3 by 3 foot. | 53 | 38 | 20 | 88 | do | 25.00 | 80.00 | Irrigation | |
| 861 | Ed C. Hall | do | F-17 | | | 55 | 37 | 28 | 101 | do | 75.00 | 125.00 | Domestic | |
| 862 | Ponfia Rios, tenant | do | G-17 | | Dug, 4 by 4 foot. | 90 | 48 | 45 | 91 | do | 50.00 | 75.00 | do | |
| 863 | Antonio Machado | do | F-17 | | Bored, 12-inch | 66 | 59 | 23 | 71 | Hand | | | Stock | |
| 864 | L. Sentons | do | F, G-17 | | Dug, 3 by 3 foot. | 66 | 56 | 15 | | do | | | Not used | |
| 865 | J. J. Machado | do | F-17 | 1886 | Dug, 4 by 4 foot. | 58 | 39 | 23 | | do | | | Domestic | |
| 866 | Antonio Machado | do | G-17 | | Dug, 3 by 3 foot. | 75 | 42 | 36 | 101 | Wind | | 75.00 | do | |
| 867 | Mr. McGarry | do | F-17 | | Bored, 7-inch | 48 | 41 | 28 | | do | 35.00 | 75.00 | Not used | |
| 868 | Geo. Rose | do | F-17 | 1895 | do | 58 | 38 | 48 | 68 | do | 50.00 | 75.00 | Domestic | |
| 869 | Mrs. E. Griffin | do | F-17 | | do | 62 | 45 | 30 | 76 | do | 35.00 | 75.00 | do | |
| 870 | John Rose | do | F-17 | 1902 | do | 64 | 42 | 38 | 79 | do | 50.00 | 60.00 | do | |
| 871 | J. B. B. Lelong | do | F-17 | 1883 | Dug, 3 by 3 foot. | 70 | 50 | 30 | 101 | do | 35.00 | 75.00 | do | |
| 872 | Henry Schimmel | do | F-17 | | Dug, 18-inch diameter. | 73 | 52 | 35 | 50 | do | 75.00 | 100,00 | do | |
| 874 | Artesian Water Co. | Santa Monica | B-15 | 1903 | Bored, 12-inch | 250 | 220 | 186 | 83 | Gas | | | do | 35 |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 875 | Artesian Water Co | Santa Monica | B-15 | 1902 | Bored, 10-inch | 237 | 220 | 164 | 72 | Compressed air | | | Domestic | 16 |
| 876 | do | do | B, C-15 | 1900 | do | 230 | 221 | 150 | | | | | Not used | |
| 877 | do | do | C-14, 15 | | Dug, 1 by 4 foot | 225 | 222 | 4 | 50 | Hand | | | Domestic | |
| 878 | do | do | C-14 | | Bored, 7-inch | 230 | 226 | | 51 | | | | Not used | |
| 879 | do | do | C-14 | | Dug, 5 by 5 foot, 30 feet; bored, 8-inch. | 250 | 220 | | 72 | Tunnel | | | Domestic | |
| 880 | do | do | C-14 | | Dug, 6 by 6 foot, 30 feet; bored, 12-inch, 59 feet. | 235 | 215 | 89 | 88 | do | | | do | |
| 881 | do | do | C-14 | | Dug, 4 by 5 foot, 20 feet; bored, 6-inch, 248 feet. | 235 | 215 | 268 | 88 | do | | | do | |
| 882 | do | do | C-14 | | Dug, 4 by 5 foot, 20 feet; bored, 6-inch, 120 feet. | 235 | 217 | 140 | 85 | do | | | do | |
| 883 | do | do | C-14 | | Dug, 4 by 5 foot, 30 feet; bored, 10-inch, 270 feet. | 235 | 211 | 300 | 86 | do | | | do | |
| 884 | do | do | C-14 | | Dug, 4 by 5 foot, 30 feet; bored, 7-inch. | 235 | 205 | | 86 | do | | | do | |
| 885 | do | do | C-14 | | Bored, 12-inch | 235 | 213 | 55 | 85 | | | | | |
| 886 | do | do | C-14 | | do | 235 | 212 | 56 | 85 | | | | | |
| 887 | do | do | C-14 | | do | 235 | 212 | 90 | 85 | | | | | |
| 888 | do | do | C-14 | | do | 235 | 212 | 90 | 85 | | | | | |
| 889 | do | do | C-14 | | Dug, bored, 12-inch. | 235 | 215 | 89 | 88 | Tunnel | | | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 890 | H. T. Maloy | do | B-16 | 1899 | Bored, 7-inch | 150 | 34 | 175 | 71 | Wind | | | do | |
| 891 | Daniel Maloy | do | B-16 | 1899 | do | 150 | 33 | 145 | 75 | do | $160.00 | $75.00 | do | |
| 892 | Mr. Dunham | do | B-15 | | do | 175 | 105 | 275 | | | | | Not used | |
| 893 | do | do | B-15 | | do | 175 | 103 | 99 | 47 | Wind | 100.00 | | Domestic | |
| 894 | H. T. Maloy | do | B,C-15 | 1902 | Bored, 12-inch | 180 | 122 | 280 | | | | | Not used | |
| 895 | Mrs. J. E. Boyce | do | B-15 | 1895 | Bored, 7-inch | 190 | 110 | 104 | 46 | Wind | 125.00 | 100.00 | Domestic | |
| 896 | Phillip Flynn | do | B-15 | 1886 | do | 210 | 86 | 170 | 36 | do | | | do | |
| 897 | Roy Jones | do | B-15 | | Bored, 12-inch | 200 | 66 | 900 | | | 3,000.00 | | Not used | |
| 898 | John Carsons | do | B-16 | 1902 | Bored, 7-inch | 167 | 57 | 191 | 73 | Wind | 257.85 | 800.00 | Domestic | |
| 899 | Golden State Land and Floral Co. | do | B-16 | 1901 | do | 153 | 43 | 151 | 58 | Gas | | | Irrigation | |
| 900 | Miss M. J. Webster | do | B-16 | 1897 | Bored, 6-inch | 153 | 54 | 114 | 46 | Wind | 100.00 | | Domestic | |
| 901 | John E. Hackett | do | B-16 | | Bored, 7-inch | 150 | 49 | 135 | 72 | do | 150.00 | | do | |
| 902 | S. E. Penn | do | A-16 | 1903 | do | 130 | 40 | 134 | | do | 167.50 | 180.00 | do | |
| 903 | Wm. Campbell | do | A-16 | 1898 | do | 133 | 40 | 150 | 62 | do | 200.00 | 100.00 | do | |
| 904 | B. L. Balsley | do | A-16 | 1900 | do | 120 | 51 | 134 | 61 | Gas | 185.00 | 450.00 | do | 5 |
| 905 | W. Arnett | do | A-16 | 1895 | do | 112 | 26 | 100 | 98 | Wind | 100.00 | 75.00 | do | |
| 906 | United Electric Gas and Power Co. | do | A-16 | | do | 100 | 35 | 200 | | Steam | | | Manufacturing | |
| 907 | Santa Monica Steam Laundry. | do | A-17,16 | 1902 | Bored, 12-inch | 90 | 40 | 108 | 76 | do | 190.00 | | Laundry | |
| 908 | J. R. Armstrong | do | A-16,17 | 1901 | Dug, 4 by 6 foot | 99 | 40 | 75 | 68 | Gas | 1,000.00 | 750.00 | Irrigation | 20 |
| 909 | C. Johnson | La Ballona | B-17 | 1890? | Dug, 3 by 3 foot | 100 | 47 | 56 | 47 | Wind | 60.00 | 75.00 | Domestic | |
| 910 | J. Monricas | do | B-17 | 1898 | do | 50 | 12 | 45 | 75 | do | | | | |
| 911 | E. Knecht | do | B-17 | 1896 | Dug, 7 by 7 foot | 40 | 21 | 31 | 70 | do | | 95.20 | Domestic | |
| 912 | Mr. Lee | do | B-17 | | Dug, 4 by 4 foot | 30 | 20 | 14 | 118 | do | | | | |
| 913 | Geo. Carter | do | B-17 | 1902 | Bored, 16-inch | 48 | 11 | 47 | 96 | do | 50.00 | 75.00 | Domestic | |
| 914 | Joe Burkhart | do | B-17 | 1903 | Dug, 8 by 10 foot | 38 | 30 | 30 | 200+ | Gas | | | Irrigation | |
| 915 | Antonio Machado | do | C-17 | | Bored, 7-inch | 60 | 35 | 34 | 53 | Wind | 50.00 | 75.00 | Domestic; stock | |
| 916 | Augustin Cota | do | C-17 | 1891 | Dug, 4 by 4 foot | 51 | 33 | 25 | 47 | Hand | | | Domestic | |
| 917 | H. W. Cripe | do | D-17 | 1893 | Bored, 7-inch | 96 | 18 | 85 | 74 | Wind | 100.00 | 100.00 | do | |
| 918 | Mrs. R Olivera | do | C-17 | 1890 | Dug, 4 by 4 foot. | 50 | 35 | 22 | 92 | Hand | | | do | |
| 919 | Augustin Cota | do | C-17 | 1890 | do | 50 | 27 | 30 | 54 | Wind | | | Stock | |
| 920 | Mrs. A. Altamiramo | do | C-17 | 1894 | do | 45 | 34 | 14 | 118 | Hand | | | Domestic | |
| 921 | Visenta de Mutaw | do | C-17 | 1898 | Dug, 3 by 3 foot. | 46 | 34 | 14 | 101 | Wind | | | do | |
| 922 | Garrison & Smith | do | B-17 | 1903 | Bored, 12-inch | 60 | 17 | 63 | 60 | Gas | | | Irrigation | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 923 | A. R. Tobey | La Ballona | B-17 | 1899 | Bored, 7-inch | 130 | 15 | 150 | 45 | Wind | $300.00 | | Domestic | |
| 924 | Joseph Burkhart | do | B-17 | | Bored, 6-inch | 130 | 20 | 440 | 56 | do | 600.00 | $250.00 | do | |
| 925 | Sheldon Tobey | do | B-17 | 1900 | Bored, 7-inch | 138 | 15 | 147 | 54 | do | 160.00 | 100.00 | do | |
| 926 | Wm. Simpson | do | B-17 | 1890 | Bored, 6-inch | 130 | 22 | 125 | 65 | do | 140.00 | 100.00 | do | |
| 927 | Andrew Comstock | do | B-17 | 1899 | Bored, 3-inch | 95 | 15 | 100 | 45 | do | | | do | |
| 928 | do | do | B-17 | 1900 | Bored, 16-inch | 90 | 15 | 90 | 48 | | | | Not used | |
| 929 | City of Santa Monica | Santa Monica | B-16 | 1896 | Bored, 7-inch | 135 | 23 | 135 | 79 | Wind | 150.00 | 125.00 | Domestic; irrigation. | |
| 930 | F. M. Doyle | La Ballona | B-16 | 1888 | do | 150 | 29 | 128 | 83 | do | 150 00 | 75.00 | Domestic | |
| 931 | H. C. Bray | do | B-16 | 1894 | do | 150 | 30 | 138 | 72 | do | 157.00 | 75.00 | do | |
| 932 | W. O. Irwin | do | B-17 | 1899 | do | 145 | 23 | 148 | 64 | Gas, wind | 165.00 | 200.00 | Domestic; irrigation. | |
| 933 | John Ban Dam | do | B-17 | 1896 | do | 145 | 23 | 147 | 50 | Wind | | | Domestic | |
| 934 | Lewis Bach | do | B-17 | 1903 | Bored, 10-inch | 148 | 19 | 140 | 81 | do | 310.00 | 200.00 | do | |
| 935 | G. S. Cornell | do | B-17 | 1902 | Bored, 7-inch | 141 | 23 | 130 | 64 | do | 150.00 | 75.00 | do | |
| 936 | Wm. Jackson | do | B-17 | 1902 | Bored, 6-inch | 136 | 23 | 126? | 67 | Gas, wind | | | Domestic; irrigation. | |
| 937 | do | do | B-17 | 1900 | do | 136 | 23 | 126 | | | 150.00 | | Not used | |
| 938 | A. Gunn | Santa Monica | A-17 | | Bored, 16-inch | 100 | 31 | 85 | | Wind | | | Domestic; irrigation. | |
| 939 | H. B. Houghton | do | A-17 | 1901 | Dug, 3 by 3 foot. | 100 | 34 | 68 | 70 | do | 70.00 | 100.00 | Domestic | |
| 940 | T. M. Holbert | do | A-17 | 1883 | do | 100 | 34 | 68 | 103 | do | 70.00 | 75.00 | do | |
| 941 | J. E. Simmons | La Ballona | A, B-17 | 1898 | Bored, 12-inch | 100 | 31 | 80 | 70 | do | 150.00 | 45.00 | do | |
| 942 | Maurice Macklin | do | A-17 | | Bored, 8-inch | 120 | 20 | 115 | 70 | do | | | do | |
| 943 | Roy Jones | Santa Monica | A-14 | | Dug, 4 by 4 foot. | 375 | 318 | 65 | 120 | Hand | | | | |
| 944 | do | do | A-13 | | do | 540 | 519 | 26 | 120 | do | | | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 945 | D. F. Dominick | La Ballona | A-17 | 1896 | Dug, 3 by 3 foot. | 60 | 21 | 42 | 109 | Wind | 50.00 | 75.00 | do | |
| 946 | J. A. Colvert | do | A-17 | 1893? | Dug, 2 by 2 foot. | 60 | 18 | 50 | 106 | do | 50.00 | 75.00 | do | |
| 947 | H. C. Morse | do | A-17 | 1903 | Bored, 7-inch | 40 | 17 | 103 | | do | 154.50 | 250.00 | do | |
| 948 | M. E. Biggs | do | A-17 | | Dug, 4 by 4 foot. | 48 | 19 | 33 | 96 | do | | | do | |
| 949 | Rance Hermann | do | A-17 | 1897 | Dug, 4-foot diameter. | 40 | 18 | 24 | | do | | | do | |
| 950 | J. Haffner | do | A-17 | 1883 | Dug, 4 by 4 foot. | 42 | 19 | 26 | 154 | do | 30.00 | 116.00 | do | |
| 951 | E. L. Hostetter | do | A-17 | 1888 | Bored, 7-inch | 50 | 17 | 39 | 67 | do | 45.00 | 75.00 | do | |
| 952 | S. Thomas | do | A-17 | 1898 | Dug, 3 by 3 foot. | 65 | 18 | 55 | 200+ | do | 60.00 | 50.00 | do | |
| 953 | Geo. McLaughlin | do | E-17 | 1892 | Bored, 7-inch | 79 | 65 | 50 | 40 | do | 50.00 | 75.00 | do | |
| 954 | Mrs. H. McKee | do | E-17 | | do | 78 | 58 | 33 | 43 | do | 40.00 | 75.00 | do | |
| 955 | Gus. Kruger | do | E-17 | | Dug, 3 by 3 foot. | 78 | 58 | 22 | 62 | Hand | | | do | |
| 956 | Mrs. M. E. Platt | do | E-17 | | do | 79 | 58 | 26 | 54 | Wind | | 75.00 | do | |
| 957 | Ballona school district | do | E-17 | | Bored, 7-inch | 82 | 50 | 52 | 60 | do | 65.00 | 100.00 | do | |
| 958 | D. J. Boynton | do | F-17 | | do | 85 | 45 | 60 | 32 | do | 75.00 | 100.00 | Domestic; irrigation. | |
| 959 | Sunset Brick and Tile Co. | Santa Monica | B-16 | 1903 | Bored, 12-inch | 160 | | | | | | | Manufacturing | |
| 961 | Mr. Kirkhoff | Los Angeles city | M-15 | | Bored, 7-inch | 200 | Dry | 59 | | | | | | |
| 962 | Wm. Bayly | do | M-16 | | do | 205 | 140 | 88 | | | | | Not used | |
| 963 | Andrew Conlan | do | M-16 | 1890 | do | 198 | 137 | 101 | 66 | Wind | | | Domestic | |
| 964 | Thos. Wolfe | do | M-16 | 1889? | Bored | 195 | 136 | 85 | | | | | Not used | |
| 965 | Dr. Phelps | do | L-16 | | Bored, 7-inch | 190 | 135? | 80? | | Wind | | | Domestic | |
| 966 | J. H. McKnight | do | M-16 | | do | 210 | 148 | 64 | | | | | Not used | |
| 968 | Berlin Dye Works | do | N-16 | 1902 | Bored, 12-inch | 220 | 145? | 120 | 59 | Electric motor | | | Manufacturing | †3 |
| 969 | L. Snodgrass | do | N-16 | 1883? | Bored, 7-inch | 225 | Dry. | 73 | | | | | | |
| 970 | E. H. Limsenbard | do | M-15 | 1882? | do | 225 | Dry. | 80 | | | | | | |
| 971 | Los Angeles Interurban Railway. | do | M-15 | 1902? | Bored, 9-inch | 235 | 110? | 625 | | | | | Not used | |
| 972 | Otto Wandrey | do | L-15 | 1893? | Bored, 7-inch | 215 | 151 | 67 | 59 | Wind | | | Domestic | |
| 973 | A. H. Van Guysling | do | L-15 | 1884? | Dug, 60 feet; bored, 18 feet. | 220 | 154 | 78 | 72 | do | | | do | |
| 974 | Geo. R. Cooper | do | L-15 | 1884? | Bored | 200 | 125? | 175 | 51 | do | | | do | |
| 975 | C. P. Clark | do | L-15 | 1894? | Bored, 7-inch | 215 | 125? | 120? | 74 | do | | | do | |
| 976 | Westlake Oil Co. | do | L-13 | 1901 | Bored, 7¼-inch, 385 feet; bored, 5¾-inch, 155 feet. | 275 | | 510 | | | | | Boilers | |

*Wells in Santa Monica quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well. | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 977 | Westlake Oil Co | Los Angeles city | L-13 | 1902 | Bored, 6-inch | 280 | 255 | 1,500 | 150+ | | | | Boilers | |
| 978 | A. K. Waters | do | M-13 | 1897 | Dug, 4 by 4 foot, 76 feet; bored, 7-inch, 33 feet. | 405 | 339 | 109 | 29 | Wind | $400.00 | | Domestic | |
| 979 | Mr. Thayer | do | N-12 | | Dug, 3½-foot diameter. | 390 | 345 | 61 | 58 | do | | | do | |
| 980 | E. P. Blackmar | Los Felis | M-11 | | Dug, 3 by 3 foot. | 390 | 272 | 22 | 69 | do | | | Domestic; irrigation. | |
| 981 | E. Beck | do | M-12 | 1902 | do | 400 | 557? | 45 | 62 | do | | | Domestic | |
| 982 | G. M. Thayer | do | M-10 | | Dug, 4 by 4 foot, 41 feet; bored, 7-inch, 9 feet. | 440 | 400 | 50 | 140 | do | | | do | |
| 983 | L. K. Westcott | do | M-10 | | Dug, 4-foot diameter. | 450 | 370 | 79 | 69 | do | | | do | |
| 984 | Mrs. S. G. Thompson | do | M-10 | 1892? | Dug, 20-inch diameter. | 500 | 485 | 18 | 29 | do | | | do | |
| 985 | Jose Salazar | do | N-10 | 1903 | Dug, 3 by 4 foot. | 450 | 438 | 13 | | Hand | | | do | |
| 986 | L. A. City | do | N-11 | 1898 | Dug, 4 by 4 foot. | 435 | 396 | 49 | | do | | | Stock | |
| 987 | Jose Garcia | do | N-10 | 1903 | do | 450 | | 33 | | Wind | | | Domestic | |
| 988 | C. A. McCoy | Los Angeles city | N-12 | 1903? | Dug, 4 by 6 foot. | 500 | 474 | 28 | 53 | do | | | do | |
| 989 | Haggard & Shepard | do | N-13 | | Dug, 4-foot diameter. | 390 | 361 | 31 | 141 | | | | Not used | |
| 991 | Frank Whitmore | do | N-11 | 1903 | Dug, 4 by 4 foot. | 480 | 436 | 46 | 31 | Hand | | | Stock | |
| 992 | Jacob Fader | do | N-12 | 1896 | Dug, 5 by 5 foot. | 440 | 416 | 28 | 40 | Wind | | | Domestic | |
| 993 | Mr. Clark | do | N-12 | 1900? | Dug, 3 by 4 foot. | 425 | 398 | 33 | 52 | do | | | do | |
| 994 | John Maier | do | N-12 | 1899? | Dug | 460 | 444 | 22 | 62 | do | | | do | |
| 995 | Elysian Water Co. | do | N-12 | 1899 | do | 550 | 528 | 32 | 22 | do | | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 996 | Crystal Water Co. | do | N-12 | | Dug, 8 foot diameter. | 580 | | 40 | 27 | do | | | do | | |
| 997 | C. R. Cummings | do | N-12 | 1903 | Dug, 4 by 4 foot. | 600 | 542 | 65 | 25 | do | | | do | | |
| 998 | Felipe Botiller | do | N 15 | 1893 | Bored, 7-inch | 240 | | 100 | | do | | | Not used | | |
| 999 | Pacific Electric R. R. Co. | Los Bueyes | F-16 | 1903 | Bored, 12-inch | 110 | 75 | 125 | | Gas | | | Power house | | |
| 1000 | H. D. Lombard | Rodeo de las Aguas. | H-14 | 1905 | Bored, 12-inch (3). | 150 | 114 | 170 | | Not installed | | | Will be used for irrigation. | | |

*Wells in Redondo quadrangle.*

* Cost of well and equipment combined. + Tank included, in column "Cost of machinery." † Yield estimated or statement of owner taken. ? Doubtful.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000 | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ocean Park Water Co | La Ballona | B-1 | 1903 | Bored, 10-inch | 75 | 42 | 87 | 82 | Gas | | | Domestic | |
| 2 | do | do | B-1 | 1902 | do | 75 | 42 | 88 | 79 | do | | | do | |
| 3 | M. Baldridge | do | B-1 | 1896 | Bored, 6-inch | 90 | 40 | 100 | 79 | Wind | | | do | |
| 4 | W. S. Vawter | do | B-1 | | Bored | 87 | 42 | 80 | 78 | Wind, gas | | | Domestic; irrigation. | |
| 5 | A. P. Olivares | do | B-1 | 1892 | Dug, 4 by 4 foot. | 42 | 14 | 32 | 73 | Wind | $40.00 | $75.00 | Domestic | |
| 6 | E. J. Vawter | do | B-1 | | Dug, 5 by 10 foot | 40 | 12 | 89 | 67 | Gas | | | Irrigation | 25 |
| 7 | D. J. Machado | do | B-1 | 1888 | Dug, 3 by 3 foot. | 41 | 12 | 30 | 75 | Wind | 30.00 | 75.00 | Domestic | |
| 8 | M. Higuera | do | B-1 | | do | 38 | 12 | 30 | 82 | do | 30.00 | 75.00 | do | |
| 9 | I. A. Jameson | do | B-1 | 1900 | Dug, 3 by 4 foot. | 38 | 12 | 30 | 79 | Gas | 30.00 | | Manufacturing | |
| 10 | United Electric Gas and Power Co. | do | B-1 | 1903 | Dug, 23 feet; bored, 12-inch, 28 feet. | 38 | 14 | 51 | 78 | Steam | 100.00 | | do | |
| 11 | E. J. Vawter | do | B-1 | | Bored, 7-inch | 40 | 13 | 30 | 102 | Wind | 35.00 | 75.00 | Domestic | |
| 12 | Abbott Kinney & Co | do | B-1 | 1902 | Bored, 15-inch | 35 | 17 | 93 | 86 | Gas | | | do | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | Abbott Kinney & Co. | La Ballona | B-1 | 1900 | Bored, 10-inch | 35 | 19 | 99 | 86 | Gas | | | Domestic | |
| 14 | do | do | B-1 | 1892 | Bored, 7-inch | 35 | 19 | 100 | 86 | do | | | do | |
| 15 | Mrs. Mary Mead | do | B-1 | 1897 | Dug, 3 by 3 foot | 15 | 45 | 32 | 68 | Wind | | | do | |
| 16 | Thos. Menzier | do | A, B-1 | 1898 | do | 34 | 14 | 22 | | do | $25.00 | $75.00 | do | |
| 17 | Ocean Park Laundry | do | A-1 | 1903 | Dug, 23 feet; bored, 8-inch, 74 feet. | 45 | 15 | 107 | 109 | Steam | 125.00 | | Laundry | |
| 18 | A. D. Keating | do | C-1 | 1898 | Dug, 4 by 4 foot | 30 | 13 | 19 | 72 | Wind | | 75.00 | Domestic | |
| 19 | Geo. Lawson | do | C-1 | 1902 | Dug, 3 by 4 foot | 30 | 13 | 20 | 74 | Hand | | | Irrigation | |
| 20 | H. Knutson | do | C-1 | | Bored, 10-inch | 22 | 14 | 45 | | Gas | | | do | |
| 21 | Winan & Son | do | C-1 | 1903 | Bored, 12-inch | 28 | 12 | 40 | 72 | | | | | |
| 22 | Wm. Sweeney | do | C-1 | | Dug, 3 by 3 foot | 30 | 13 | 22 | 77 | Wind | | 45.00 | Domestic; stock | |
| 23 | B. Luegel | do | C-1 | 1895 | Dug, 4 by 4 foot | 30 | 13 | 19 | 100 | Hand | 20.00 | | Domestic | |
| 24 | C. J. Frederick | do | C-1 | 1898 | do | 29 | 13 | 18 | 108 | Wind | 20.00 | | do | |
| 25 | L. C. Miller | do | C-1 | 1901 | Dug, 31 feet; bored, 12-inch, 39 feet. | 42 | 24 | 70 | 91 | Gas | 200.00 | 950.00 | Irrigation | †90 |
| 26 | do | do | C-1 | 1893 | Bored, 7-inch | 42 | 24 | 76 | 86 | Wind | 76.00 | 100.00 | Domestic | |
| 27 | Wm. Hume | do | C-1 | | Bored, 12-inch | 26 | 15 | 84 | | Gas | 100.00 | 1,000.00 | Irrigation | †50 |
| 28 | do | do | C-1 | 1895 | Bored, 14-inch | 26 | 16 | 22 | | do | | | do | |
| 29 | do | do | C-1 | | do | 26 | 16 | 22 | | do | | | do | |
| 30 | do | do | C-1 | | Dug, 4 by 4 foot | 26 | 16 | 17 | 98 | Wind | | | Domestic | |
| 31 | do | do | C-1 | | do | 25 | 19 | 10 | | | | | Stock | |
| 32 | E. Tanny | do | C-1 | | do | 26 | 20 | 12 | 86 | Horsepower | | | Irrigation | |
| 33 | A. Soreet | do | C-1 | 1897 | Dug, 3 by 3 foot | 25 | 19 | 12 | 86 | Wind | | | Domestic | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | Mrs. M. J. D. Higuera | do | C-2 | 1891 | Dug, 3½ by 3½ foot. | 21 | 18 | 9 | 80 | do | | | do | | |
| 35 | Recreation Gun Club | do | C-2 | | Bored, 12 inch | 20 | 14 | 44 | 74 | Gas | | | Duck pond | | 55 |
| 36 | do | do | C-2 | | do | 20 | 14 | 40 | 73 | Wind, gas | | | do | | |
| 37 | Frank King | do | C-1 | | Bored, 7 inch | 30 | 23 | 20 | 73 | Wind | 25.00 | 75.00 | Domestic; stock | | |
| 38 | E. Kinney | do | B-1 | | Dug, 4 by 4 foot. | 27 | 15 | 14 | 78 | do | | | Domestic | | |
| 39 | Los Angeles Pacific Rwy. | do | B-1 | | Dug, 6-foot diameter. | 28 | 8 | 30 | 71 | Steam | | | Boilers | | |
| 40 | Artesian Water Co. | do | D-2 | | Bored, 7-inch | 25 | 15 | 80 | 83 | Wind | | | Domestic | | |
| 41 | do | do | D-1 | 1883 | Bored, 6-inch | 27 | 15 | 140 | 83 | Wind, steam | 100.00 | 200.00 | Creamery | | |
| 42 | do | do | D-2 | 1888 | do | 25 | 15 | 80 | | Wind | | | Stock | | |
| 43 | do | do | D-2 | 1888 | do | 25 | 15 | 80 | 85 | do | 80.00 | 75.00 | do | | |
| 44 | do | do | D-1 | 1896 | Dug, 6 by 8 foot, 30 feet; bored, 18-inch, 76 feet. | 47 | 21 | 106 | 83 | Steam | | | Irrigation | | |
| 45 | do | do | D-1 | 1896 | Bored, 6-inch | 47 | 21 | 80 | 83 | Wind | | 65.00 | Domestic; irrigation. | | |
| 46 | do | do | D-2 | 1888 | do | 17 | 17 | 100 | 92 | Artesian | | | Stock | | 1 |
| 47 | H. W. Chase | do | D-1 | | Dug, 3 by 3 foot. | 51 | 24 | 30 | 86 | Wind | 30.00 | 65.00 | Domestic | | |
| 48 | Los Angeles Co. | do | D-1 | | Bored, 7-inch | 52 | 24 | 30 | 75 | do | | | Stock; roads | | |
| 49 | John Lachenmyer | do | D-1 | 1902 | Bored, 12-inch | 66 | 36 | 58 | 89 | Gas | 300.00 | 1,400.00 | Irrigation | | |
| 50 | T. L. Gooch | do | D-1 | 1902 | Bored, 7-inch | 54 | 25 | 36 | 80 | Wind | | | Domestic | | |
| 51 | Ira Ballard | do | C-1 | 1891 | do | 47 | 29 | 48 | 82 | do | 60.00 | 75.00 | do | | |
| 52 | E. Machado | do | C-1 | 1900 | Dug, 3 by 3 foot. | 48 | 31 | 20 | 82 | Hand | | | do | | |
| 53 | John Lugo | do | C-1 | 1900 | do | 50 | 26 | 27 | 89 | Wind | | 75.00 | do | | |
| 54 | E. F. Boyer | do | D-1 | 1903 | Dug, 4 foot diameter. | 48 | 30 | 20 | 76 | do | 40.00 | 100.00 | do | | |
| 55 | L. B. Boyer | do | C-1 | 1893 | Dug, 3 by 3 foot. | 45 | 30 | 20 | 72 | do | 30.00 | 125.00 | do | | |
| 56 | Machado school district. | do | D-1 | 1895 | Bored, 7-inch | 48 | 28 | 33 | 87 | do | 40.00 | 100.00 | do | | |
| 57 | P. B. Chase | do | D-1 | | do | 47 | 30 | 26 | 77 | do | 30.00 | 100.00 | do | | |
| 58 | P. B. Riggins | do | D-1 | | Bored, 8-inch | 45 | 31 | 25 | 82 | do | 30.00 | 100.00 | Domestic; stock | | |
| 59 | do | do | D-1 | | Dug, 4 by 6 foot. | 45 | 31 | 50 | | Gas | | | Irrigation | | †30 |
| 60 | J. J. Lachenmeyer | do | D-1 | 1899 | Bored, 7-inch | 48 | 22 | 36 | 89 | Wind | | | Domestic | | |
| 61 | W. F. McConnell | do | D-1 | 1895 | Dug, 4 by 8 foot. | 52 | 26 | 30 | 73 | do | 100.00 | 150.00 | do | | |
| 62 | H. W. Chase | do | D-1 | 1891 | Bored, 7-inch | 53 | 26 | 31 | 67 | do | 35.00 | 100.00 | do | | |
| 63 | P. B. Chase | do | D-1 | | Dug, 4 by 6 foot. | 55 | 27 | 35 | 73 | do | 75.00 | 250.00 | Irrigation | | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64 | J. Hefflebower | La Ballona | D, E-1 | 1895 | Dug, 3 by 4 foot. | 51 | 25 | 28 | 73 | Wind | | $125.00 | Domestic | |
| 65 | H. Lehman | do | E-1 | 1891 | Dug, 4 by 4 foot. | 40 | 25 | 16 | 120 | Hand | | | do | |
| 66 | A. D. Keating | do | E-2 | | Dug, 3½ by 3½ foot. | 25 | 21 | 10 | 130 | do | | | do | |
| 67 | do | do | D-2 | 1903 | Bored, 12-inch | 24 | 24 | 32 | 76 | Artesian | $50.00 | | Stock | |
| 68 | do | do | D-2 | 1898 | Bored, 7-inch | 18 | 18 | 500 | | do | | | do | †1 |
| 69 | Los Angeles Co | do | E-1 | | do | 60 | 31 | 53 | 70 | Wind | 60.00 | 100.00 | Roads | |
| 70 | John J. Charnock | do | E-1 | 1882 | do | 60 | 28 | 69 | 78 | Hand | 70.00 | | Domestic; stock | |
| 71 | do | do | E-1 | | do | 60 | 30 | 38 | 61 | do | 40.00 | | Domestic | |
| 72 | M. D. Chavez | do | E-1 | 1900 | Dug, 3 by 3 foot. | 51 | 31 | 21 | 90 | Wind | 20.00 | 75.00 | do | |
| 73 | P. Chavez | do | E-1 | 1895 | Dug, 4 by 4 foot. | 49 | 32 | 21 | 103 | do | 20.00 | 65.00 | do | |
| 74 | D. I. Russell | do | E-1 | | do | 52 | 42 | 15 | 103 | do | 20.00 | 50.00 | do | |
| 75 | Mrs. L. A. Sanford | do | E-1 | 1878 | do | 48 | 38 | 13 | 103 | Hand | | | do | |
| 76 | Mrs. Ida Niles | do | F-2 | | do | 23 | 17 | 14 | 80 | Wind | | | do | |
| 77 | do | do | E-2 | | do | 23 | 18 | 13 | 86 | Hand | | | Stock | |
| 78 | John J. Charnock | do | C-2 | | Dug, 3½ by 3½ foot. | 17 | 13 | 10 | 81 | Wind | | | do | |
| 79 | A. D. Keating | do | C-2 | | Dug, 3 by 3 foot. | 17 | 13 | 10 | 79 | do | 15.00 | | do | |
| 80 | Beach Land Co | Sausal Redondo | D-4 | | Bored, 12-inch | 65 | 4 | 256 | 71 | | 512.00 | | Domestic | |
| 81 | do | do | D-4 | 1902 | do | 66 | 4 | 268 | 71 | Gas | 405.00 | | do | |
| 82 | M. Leidel | La Ballona | F 1 | 1897 | Bored, 7⅞-inch | 35 | 31 | 260 | 65 | Wind | | | Domestic; stock | |
| 83 | do | do | F 1 | 1883 | Bored, 7-inch | 35 | 31 | 30 | 103 | Hand | | | Not used | |
| 84 | Joe Mesmer | do | F-1 | 1900 | Bored, 4-inch | 27 | 23 | 33 | 230+ | do | | | Domestic | |
| 85 | do | do | F-1 | 1900 | Dug, 5 by 5 foot. | 27 | 22 | 13 | | do | | | do | |
| 86 | do | do | F 2 | | Dug, 4 by 4 foot. | 27 | 21 | 14 | 67 | do | | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 87 | do | do | F-2 | | do | 27 | 16 | 15 | 63 | do | | | Stock | | |
| 88 | do | do | F-2 | | do | 23 | 19 | 9 | 60 | do | | | Domestic | | |
| 89 | do | do | F-2 | 1901 | do | 23 | 16 | 10 | 108 | do | | | do | | |
| 90 | do | do | E-2 | | do | 17 | 9 | 25 | 173 | do | 25.00 | | Stock | | |
| 91 | R. Machado | do | E-2 | | Dug, 3 by 3 foot. | 17 | 10 | 10 | 89 | do | | | Domestic | | |
| 92 | J. Mesmer | do | E-2 | | Dug, 4 by 4 foot. | 20 | 15 | 10 | 89 | do | | | do | | |
| 93 | do | do | E-2 | | Bored, 4-inch | 16 | 16 | | 71 | Artesian | | | Stock | | 1 |
| 94 | do | do | E-3 | 1902 | Bored, 12-inch | 15 | 15 | 45 | 72 | Gas, artesian | | | Duck pond | | |
| 95 | do | do | E-3 | 1902 | do | 15 | 15 | 92 | 72 | do | | | do | | |
| 96 | do | do | E-3 | 1902 | do | 15 | 15 | 87 | 72 | do | | | do | | |
| 97 | do | do | E-3 | | do | 15 | 15 | 38 | 72 | do | | | do | | |
| 98 | do | do | E-3 | 1902 | do | 15 | 15 | 57 | 72 | do | | | do | | |
| 99 | do | do | E-3 | 1902 | Bored, 6½-inch | 21 | 16 | 24 | 72 | Hand | | | Domestic | | |
| 100 | do | do | E-2 | | Dug, 4 by 4 foot. | 20 | 16 | 9 | 86 | do | | | Stock | | |
| 101 | A. D. Keating | do | F-1 | 1902 | do | 35 | 30 | 8 | 230+ | Wind | | | do | | |
| 102 | Mrs. Ida Niles | do | F-1 | 1897 | Dug, 3 by 3 foot. | 40 | 35 | 9 | 101 | Hand | | | Domestic | | |
| 103 | Manuel Perez | do | F-1 | 1881 | do | 44 | 39 | 10 | 106 | do | | | do | | |
| 104 | M. Lugo | do | F-1 | 1902 | do | 49 | 43 | 12 | 94 | do | | | do | | |
| 105 | C. Peters | do | F-1 | | Dug, 3½ by 3½ foot. | 48 | 39 | 14 | 115 | do | | | do | | |
| 106 | Joseph Faulk | do | F-1 | | Dug, 3 by 3 foot. | 49 | 41 | 12 | 96 | do | | | do | | |
| 107 | A. Machado | do | F-1 | | do | 40 | 34 | 10 | 94 | do | | | Stock | | |
| 108 | B. Machado | do | F-1 | | Dug, 3 by 4 foot. | 40 | 36 | 8 | 93 | Wind | | | do | | |
| 109 | Mrs. Ida Niles | do | F-1 | 1902 | Dug, 4 by 4 foot. | 46 | 31 | 17 | 158 | Hand | 20.00 | | Domestic | | |
| 110 | C. Oliveras | do | G-1 | | Dug, 3½ by 3½ foot. | 48 | 36 | 14 | 94 | do | | | do | | |
| 111 | do | do | G-1 | 1889 | Dug, 2 by 3 foot. | 70 | 36 | 37 | 72 | do | 35.00 | | do | | |
| 112 | A. Machado | do | G-1 | 1885 | Dug, 4 by 4 foot. | 60 | 39 | 23 | 98 | do | | | do | | |
| 113 | M. Perez | do | G-1 | 1903 | Bored, 7-inch | 100 | 21 | 96 | 76 | Wind | | 65.00 | do | | |
| 114 | L. Sentons | do | G-1 | 1903 | Bored, 8-inch | 175 | 19 | 163 | 71 | do | | 75.00 | Stock | | |
| 115 | T. Oliveras estate | do | E-1 | 1888 | Bored, 7-inch | 66 | 40 | 35 | | do | 35.00 | 75.00 | Domestic | | |
| 116 | do | do | E-1 | 1903 | Dug, 3 by 3 foot. | 66 | 22 | 27 | 82 | Hand | | | do | | |
| 117 | A. D. Keating | do | F-2 | | do | 35 | 31 | 11 | 90 | do | | | do | | |
| 118 | L. Sentons | do | F, G-1 | | Dug, 6 by 6 foot. | 50 | 46 | 9 | 98 | Wind | | | Domestic; stock | | |
| 119 | L. Wilhelm | Agua de la Centela | G-2 | | Dug, 3½ by 3½ foot. | 48 | 35 | 17 | 160 | do | | | do | | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 120 | L. Wilhelm | Agua de la Centela | G-2 | | Bored, 7-inch | 105 | 32 | 90 | | Wind | | | Stock | |
| 122 | D. Freeman | do | H-3 | | do | 100 | 14 | 88 | 34 | do | | | Domestic; stock | |
| 123 | R. B. Weihl | do | G-3 | 1889 | | 132 | 20 | 130 | 49 | do | | | | |
| 124 | D. Freeman | Sausal Redondo | G-3, 4 | | Bored, 7-inch | 126 | 8 | 124 | | Horsepower | | | Stock | |
| 125 | do | do | F-4 | | | 125 | 5 | 133 | 51 | Wind | | $200.00 | Domestic; stock | |
| 126 | do | do | F-3 | | | 135 | 48 | 141 | 91 | do | | 125.00 | do | |
| 127 | do | do | D-3 | 1903 | Bored, 8-inch | 180 | 5 | 300 | 60 | do | $225.00 | | Stock | |
| 128 | L. Wilhelm | Sec. 20, T. 2 S., R. 14 W. | H-2 | | | 160 | 32 | 157 | 71 | do | | | Domestic; stock | |
| 129 | H. D. Abrams | Agua de la Centela | H-2 | 1889 | Bored, 7-inch | 135 | 111 | 150 | 33 | do | 150.00 | 75.00 | Domestic | |
| 130 | Mr. Merrill | do | H-2 | | do | 110 | 30 | 170 | 52 | Gas | | | do | |
| 131 | Mrs. D. M. Slawson | do | H-3 | 1902 | do | 110 | 30 | 182 | 49 | do | | | Domestic; irrigation. | |
| 132 | A. Cartrite | Aguaje de la Centinela. | H-3 | 1903 | do | 110 | 30 | 183 | | Not installed | 200.00 | | Domestic | |
| 133 | D. Freeman | Sausal Redondo | F-4 | 1893 | do | 120 | | 77 | | | 100.00 | | Not used | |
| 134 | do | do | E-5 | | do | 75 | 2 | 75 | 60 | Wind | | | Domestic | |
| 135 | do | do | E-5 | 1893 | do | 72 | 3 | 71 | 60 | do | 75.00 | 50.00 | do | |
| 136 | do | do | F-5 | 1883 | do | 112 | 12 | 120 | 54 | do | 140.00 | 65.00 | Domestic; stock | |
| 137 | Jack Smith | do | G-4 | | Dug, 3 by 3 foot | 106 | 26 | 82 | 63 | do | 80.00 | | Domestic | |
| 138 | D. Freeman | do | G-4 | | Bored, 10-inch | 97 | 20 | 110 | | do | 200.00 | 75.00 | Stock | |
| 139 | K. D. Wise | do | G-6 | | Bored, 7-inch | 100 | 19 | 101 | 60 | do | 125.00 | 75.00 | Domestic; stock | |
| 140 | do | do | G-6 | | Bored, 10-inch | 100 | 23 | 200+ | 60 | Not raised | | | Not used | |
| 141 | do | do | G-6 | | do | 100 | 20 | 505+ | 60 | do | | | do | |
| 142 | do | do | G 6 | | Bored, 12-inch | 100 | 20 | 650 | 60 | do | | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 143 | do | do | G-6 | | Bored, 7-inch | 100 | 19 | 98 | 57 | Gas | | | Stock | | |
| 144 | do | do | G-6 | | do | 100 | 3 | 108 | | Wind | | | Domestic; stock | | |
| 145 | Dr. Herst | do | G-6 | | do | 100 | 10 | 131 | 55 | do | 150.00 | 100.00 | do | | |
| 146 | J. S. Vosberg | do | G-6 | | do | 100 | 10 | 114 | 57 | do | 125.00 | 75.00 | Domestic | | |
| 147 | do | do | G-6 | | do | 100 | 15 | 124 | 60 | do | | 100.00 | Domestic; stock | | |
| 148 | do | do | F-6 | 1888? | do | 105 | 3 | 109 | 57 | do | 125.00 | 75.00 | do | | |
| 149 | Geo. Stimpson | do | F-6 | 1895 | do | 125 | 2 | 257 | | Hand | 400.00 | | Domestic | | |
| 150 | Ed. Vail | do | F-7 | 1898 | Bored, 9-inch | 145 | 5 | 200 | 63 | Wind | | | do | | |
| 151 | G. Dagey | do | G-7 | 1893 | Bored, 7-inch | 89 | 29 | 175 | 47 | do | 200.00 | 100.00 | do | | |
| 152 | Wiseburn school district. | do | G-7 | | do | 95 | 13 | 93 | 51 | do | 100.00 | 65.00 | do | | |
| 153 | J. S. Vosberg | do | H-6 | | do | 94 | 10 | 117 | 72 | do | 125.00 | 75.00 | do | | |
| 154 | Pomeroy & Harrison | do | H-6 | 1871 | do | 80 | 30 | 300+ | 49 | do | | 100.00 | Domestic; stock | | |
| 155 | E. D. Neff | do | H-5 | 1902 | Bored, 12-inch | 74 | 20 | 185 | | Gas | 260.00 | 2,700.00 | Irrigation | | |
| 156 | Frank Dickens | do | H-5 | | Bored, 10-inch | 77 | 24 | 200 | 220 | do | 300.00 | 2,000.00 | do | | †75 |
| 157 | D. Freeman | do | H-5 | | Bored, 7-inch | 85 | 20 | 100? | | Wind | | | Domestic | | |
| 158 | Inglewood Water Co. | do | H-4 | | do | 87 | 27 | 50 | | | 55.00 | | Not used | | |
| 159 | W. H. Neher | do | H-4 | 1903 | Bored, 12-inch | 105 | 28 | 204 | 63 | Gas | 342.90 | 2,500.00 | Irrigation | | †50 |
| 161 | E. Forney | do | H-4 | 1895? | Dug, 3 by 2 foot | 110 | 66 | 59 | 54 | Wind | 60.00 | 65.00 | Domestic | | |
| 162 | Mrs. E. C. Johnson | do | H-4 | 1898 | Bored, 7-inch | 108 | 38 | 200 | 43 | do | 250.00 | 65.00 | do | | |
| 163 | H. A. Whistler | do | I-4 | 1903 | Bored, 12-inch | 100 | 25 | 195 | 82 | Gas | 324.00 | 265.00 | do | | |
| 164 | D. Freeman | do | I-4 | | Dug, 3 by 3 foot | 85 | 37 | 62 | 106 | Wind | 65.00 | 65.00 | do | | |
| 165 | Post & Lockhart | Sec. 3, T. 3 S., R. 14 W. | J-5 | | Bored, 8-inch | 80 | 10 | 88 | 54 | do | 100.00 | 75.00 | Domestic; stock | | |
| 166 | E. W. Sisson | Sausal Redondo | I-5 | 1883 | Bored, 7-inch | 70 | 28 | 185 | 107 | do | 200.00 | 75.00 | Domestic | | |
| 167 | W. H. Kelso | do | I-5 | 1893 | Bored, 8-inch | 71 | 30 | 835 | 29 | do | 2,200.00 | 150.00 | do | | |
| 168 | Post & Lockhart | Sec. 10, T. 3 S., R. 14 W. | I-6 | 1903 | Bored, 12-inch | 65 | 23 | | 115 | Not raised | | | Not used | | |
| 169 | do | do | I-6 | 1903 | do | 65 | 20 | | 42 | Electric motor | | | Irrigation | | |
| 170 | Cochran & Williams | Sec. 15, T. 3 S., R. 14 W. | I-6 | 1900 | do | 60 | 30 | 368 | 39 | do | | | do | | †185 |
| 171 | D. H. Griffith | Aguaje de la Centinela. | H-4 | 1902 | Bored, 10-inch | 117 | 28 | 310 | 48 | Wind | 480.00 | 75.00 | Domestic | | |
| 172 | J. W. Hoff | do | H-4 | 1903 | Bored, 12-inch | 117 | 39 | 220 | 82 | do | 406.00 | 100.00 | do | | |
| 173 | Emmert Stayer | do | H-3 | 1903 | Dug, 3 by 3 foot | 120 | 35 | 103 | 78 | do | 100.00 | 75.00 | do | | |
| 174 | W. H. Kelso | Sausal Redondo | I-3 | 1899 | Bored, 8-inch | 145 | 25 | 301 | 46 | Gas | 425.00 | 1,000.00 | Domestic; irrigation. | | †16 |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 175 | D. Freeman | Sausal Redondo | I-3 | 1899 | Bored, 9½-inch | 161 | 33 | 191 | 47 | Gas | | | Domestic; irrigation. | |
| 176 | Geo. Love | do | I-3 | 1902 | Bored | 160 | 37 | 180 | 57 | Wind | $200.00 | $100.00 | Domestic | |
| 177 | P. A. Moore | do | I-3 | 1897 | Bored, 7-inch | 155 | 45 | 190 | 46 | do | 225.00 | 100.00 | Domestic; irrigation. | |
| 178 | D. Freeman | do | I-3 | | do | 161 | 33 | 160 | 46 | do | 200.00 | | Domestic | |
| 179 | Los Angeles and Redondo Rwy. Co. | do | I-2 | | Bored, 10-inch | 175 | | | 42 | do | | | Manufacturing | |
| 180 | Mr. Burkhart | do | I-2 | | Bored, 12-inch | 160 | 131 | | | Gas | | | Irrigation | |
| 181 | do | do | I-2 | | do | 160 | 131 | | | do | | | do | |
| 182 | do | do | I-2 | | Bored, 7-inch | 160 | 131 | | | do | | | do | |
| 183 | do | do | I-2 | | Bored, 12-inch | 160 | 131 | | | do | | | do | |
| 184 | Inglewood Water Co. | Sec. 22, T. 2 S., R. 14 W. | I-2 | | Bored, 7-inch | 175 | | | 43 | do | | | Not used | |
| 185 | do | do | I-2 | 1899 | Bored, 12-inch | 175 | 115 | 60 | 43 | do | 100.00 | 2,500.00 | Domestic; irrigation. | 95 |
| 186 | do | do | I-2 | | Bored, 7-inch | 175 | | | 43 | do | | | do | |
| 187 | do | do | I-2 | | Bored, 12-inch | 175 | 115 | 60 | 43 | do | | | do | |
| 207 | A. Grunwand | Sec. 21, T. 2 S., R. 14 W. | I-2 | | Bored, 7-inch | 202 | 113 | 90 | 46 | Wind | 100.00 | 75.00 | Domestic | |
| 208 | do | do | I-2 | 1903 | do | 202 | 114 | | 46 | do | | | do | |
| 209 | A. Saulque | Sec. 22, T. 2 S., R. 14 W. | I-2 | 1887 | do | 202 | 123 | 90 | 41 | do | 100.00 | 75.00 | do | |
| 210 | do | do | I-2 | 1887 | | 211 | 126 | 110 | 43 | do | 125.00 | 75.00 | do | |
| 211 | D. S. Jacobie | do | J-2 | 1906 | Bored, 7-inch | 173 | 123 | 210 | 39 | Gas | 177.00 | 300.00 | Domestic; irrigation. | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 212 | .....do..... | .....do..... | J-2..... | ..... | Dug, 3-foot diameter; bored, 7-inch. | 175 | 117 | ..... | ..... | Wind..... | ..... | ..... | Domestic..... | ..... |
| 213 | Geo. Goerlmann..... | .....do..... | J-2..... | 1903 | Bored, 7-inch... | 185 | 118 | 152 | 43 | .....do..... | 375.00 | 125.00 | .....do..... | ..... |
| 214 | John Maybohm..... | .....do..... | J-2..... | 1903 | .....do..... | 170 | 117 | 122 | 43 | .....do..... | 125.00 | 75.00 | .....do..... | ..... |
| 215 | Mrs. F. Harsh..... | .....do..... | J-1..... | 1901 | .....do..... | 174 | 129 | 245 | 39 | Gas..... | 300.00 | 325.00 | Domestic; irrigation. | ..... |
| 216 | Margaret Nelson..... | .....do..... | J-2..... | 1903 | .....do..... | 160 | 120 | 137 | 82 | Wind..... | 150.00 | 50.00 | Domestic..... | ..... |
| 217 | J. F. Nelson..... | .....do..... | J-2..... | 1903 | .....do..... | 160 | 132 | 145 | 42 | .....do..... | 250.00 | 65.00 | .....do..... | ..... |
| 218 | Hyde Park school district. | .....do..... | J-2..... | ..... | Bored, 6-inch... | 160 | 130 | 125 | 42 | .....do..... | 200.00 | 100.00 | Domestic; roads.. | ..... |
| 219 | F. B. Clark..... | .....do..... | J-2..... | 1901 | Bored, 14-inch.. | 162 | 127 | 355 | ..... | Not used..... | ..... | ..... | Not raised..... | ..... |
| 220 | W. Nahlinger..... | .....do..... | J-2..... | 1901 | Bored, 7-inch... | 160 | 120 | 110 | ..... | Wind..... | 125.00 | 75.00 | Domestic..... | ..... |
| 221 | Los Angeles Co..... | .....do..... | J-2..... | ..... | ..... | 162 | 117 | 51 | 42 | .....do..... | 50.00 | 100.00 | Roads..... | ..... |
| 222 | T. W. Sands..... | .....do..... | J-2..... | 1897 | Dug, 4 by 4 foot. | 165 | 116 | 50 | 52 | .....do..... | 50.00 | 75.00 | Domestic..... | ..... |
| 223 | F. U. Norton..... | .....do..... | J-2..... | 1896 | Dug, 3-foot diameter. | 153 | 130 | 25 | 43 | .....do..... | 25.00 | 50.00 | .....do..... | ..... |
| 224 | A. Leuzinger..... | Sec. 23, T. 2 S., R. 14 W. | J-2..... | 1895 | Dug, 4 by 4 foot. | 156 | 128 | 30 | 48 | .....do..... | 30.00 | 75.00 | .....do..... | ..... |
| 225 | J. J. Leuzinger..... | .....do..... | J-2..... | 1902 | Bored, 12-inch.. | 160 | 130 | 342 | ..... | Gas..... | 800.00 | 1,500.00 | Irrigation..... | †90 |
| 226 | .....do..... | Sec. 22, T. 2 S., R. 14 W. | J-2..... | ..... | Dug, 4 by 4 foot. | 149 | 129 | 22 | 43 | Wind..... | 25.00 | 50.00 | Domestic..... | ..... |
| 227 | A. C. Donahue..... | .....do..... | J-2..... | 1900 | Bored, 7-inch... | 165 | 128 | 150 | 43 | .....do..... | 175.00 | 100.00 | .....do..... | ..... |
| 228 | C. Lang..... | .....do..... | J-2..... | 1887 | Dug, 3 by 3 foot. | 160 | Dry. | 30 | ..... | Hand..... | 30.00 | ..... | ..... | ..... |
| 229 | A. Chapman..... | .....do..... | J-2..... | 1891 | Dug, 4-foot diameter. | 160 | Dry. | 35 | ..... | Wind..... | 40.00 | 75.00 | Domestic..... | ..... |
| 230 | Mrs. Routh..... | Sec. 27, T. 2 S., R. 14 W. | J-3..... | 1895? | Bored, 7-inch... | 200 | 113 | 100? | 48 | .....do..... | 125.00 | 100.00 | .....do..... | ..... |
| 231 | Richard Hoff..... | .....do..... | J-3..... | ..... | .....do..... | 231 | 101 | 150 | 35 | .....do..... | 175.00 | 75.00 | .....do..... | ..... |
| 232 | Mrs. S. O. Mann..... | .....do..... | J-3..... | 1889 | .....do..... | 235 | 91 | 160 | 46 | .....do..... | 175.00 | 75.00 | .....do..... | ..... |
| 233 | .....do..... | .....do..... | J-3..... | 1889 | .....do..... | 230 | 96 | 153 | 47 | Not raised..... | 175.00 | ..... | Not used..... | ..... |
| 234 | Inglewood Realty Co. | .....do..... | J-3..... | ..... | .....do..... | ..... | Dry. | 121 | ..... | .....do..... | 135.00 | ..... | .....do..... | ..... |
| 235 | F. B. Clark..... | Sec. 23, T. 2 S., R. 14 W. | J-2..... | 1888 | .....do..... | 150 | 140 | 256 | 42 | Wind..... | ..... | ..... | Domestic..... | ..... |
| 236 | .....do..... | .....do..... | J-2..... | 1877 | .....do..... | 146 | 143 | 200 | ..... | .....do..... | ..... | ..... | .....do..... | ..... |
| 237 | .....do..... | .....do..... | J-2..... | 1877 | .....do..... | 150 | 136 | 250 | ..... | Horsepower..... | ..... | ..... | Stock..... | ..... |
| 238 | J. T. Joughin..... | Paso de la Tijera.. | J-1..... | ..... | .....do..... | 152 | 135 | 75 | 39 | Wind..... | ..... | ..... | Domestic..... | ..... |
| 239 | .....do..... | .....do..... | J-1..... | 1888 | .....do..... | 140 | 139 | 116 | 22 | Not raised..... | 150.00 | ..... | Not used..... | ..... |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 240 | A. J. Thornburg | Sec. 24, T. 2 S., R. 14 W. | K-1 | 1888 | | 140 | 130 | 102 | 43 | Wind | | | Domestic; roads | |
| 241 | Wiesendanger Place | Sec. 23, T. 2 S., R. 14 W. | K-1 | 1888 | Bored, 7-inch | 140 | 132 | 344 | 20 | Not raised | | | Not used | |
| 242 | Mr. Miller | Sec. 24, T. 2 S., R. 14 W. | K-1 | | Dug, 3-foot | 140 | 130 | 60 | 48 | Hand | | | Domestic | |
| 244 | Mrs. Conley | Sec. 25, T. 2 S., R. 14 W. | K-2 | | Dug, 4 by 4 foot | 160 | 132 | 33 | 65 | do | | | do | |
| 245 | do | do | K-2 | | do | 145 | 134 | 14 | 67 | do | | | Not used | |
| 246 | do | do | K-3 | 1903 | Bored, 12-inch | 190 | 110 | 666 | | Not raised | | | do | |
| 247 | John Wagner | Sec. 36, T. 2 S., R. 14 W. | K-3 | 1889 | Bored, 7-inch | 190 | 125 | 93 | 43 | Wind | $100.00 | $75.00 | Domestic; stock | |
| 248 | Michael Wagner | do | K-3 | 1886 | do | 170 | 116 | 82 | 42 | do | 100.00 | 75.00 | do | |
| 249 | Peter Phill | do | L-3 | 1886 | do | 160 | 115 | 94 | 43 | do | 100.00 | 100.00 | Domestic | |
| 250 | Mike Mertus | Sec. 35, T. 2 S., R. 14 W. | K-3 | 1886 | do | 190 | 118 | 76 | 46 | do | | | do | |
| 251 | Will Smith | Sec. 3, T. 3 S., R. 14 W. | J-3 | | do | 80 | 20 | 108 | 57 | do | 115.00 | 75.00 | do | |
| 252 | Post & Lockhart | Sec. 2, T. 3 S., R. 14 W. | J-5 | | do | 85 | 16 | 129 | 36 | do | 150.00 | 75.00 | do | |
| 253 | do | Sec. 10, T. 3 S., R. 14 W. | J-5 | | do | 70 | 30 | | | do | | | Not used | |
| 254 | do | do | J-5 | | do | 70 | 30 | | | do | | | | |
| 255 | do | Sec. 11, T. 3 S., R. 14 W. | J-6 | 1895 | do | 62 | 32 | 200 | 43 | do | | | Domestic | |
| 256 | Frank Sparks | Sec. 15, T. 3 S., R. 14 W. | J-6 | 1893 | Dug, 4 by 4 foot | 61 | 31 | 33 | 83 | do | 35.00 | 75.00 | do | |
| 257 | E. L. Wade | do | J-7 | 1897 | Dug | 60 | 35 | 30 | 171 | do | 25.00 | 75.00 | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 258 | Post & Lockhart | Sec. 14, T. 3 S., R. 14 W. | K-6 | | Bored, 4-inch | 65 | 22 | 61 | 46 | do | 50.00 | 75.00 | do | | |
| 259 | do | Sec. 11, T. 3 S., R. 14 W. | K-5 | | Bored, 3½-inch | 150 | 38 | 164 | 42 | do | 150.00 | 75.00 | Domestic; stock | | |
| 260 | J. Reingans | Sec. 2, T. 3 S., R. 14 W. | K-4 | 1893 | Bored, 7-inch | 238 | 92 | 160 | 43 | do | 200.00 | 100.00 | Domestic | | |
| 261 | Geo. Wagner | Sec. 35, T. 2 S., R. 14 W. | K-4 | | Bored, 6-inch | 200 | | 58 | | | 60.00 | | do | | |
| 262 | do | Sec. 36, T. 2 S., R. 14 W. | K-4 | 1891 | Bored, 7-inch | 200 | 128 | 84 | 66 | Wind | 100.00 | 75.00 | do | | |
| 263 | Davison Sisters | Sec. 24, T. 2 S., R. 14 W. | K-2 | 1873? | do | 140 | 126 | | 46 | do | | 75.00 | do | | |
| 264 | Hermosa Beach Water Co. | Sausal Redondo | G-9 | 1903 | Bored, 10-inch | 80 | 0 | 502 | | Gas | | 9,000.00 | do | | |
| 265 | do | do | F-10 | | Hydraulic | 50 | | 148? | | | | | | | |
| 266 | Mr. Cook | do | G-8 | | Bored, 7-inch | 90 | 14 | 130 | 51 | Wind | 150.00 | 75.00 | Domestic; stock | | |
| 267 | Manhattan Beach Co. | do | F-8 | | Bored, 10-inch | 85 | 20 | 250 | 84 | Gas | | | Domestic | | |
| 268 | Mr. Peck | do | E-8 | | Bored | 105 | | 600 | 84 | do | | | Not used | | |
| 269 | W. Smith | do | F-9 | 1892 | Bored, 7-inch | 150 | 30 | 172 | 53 | Wind | 200.00 | 65.00 | Domestic | | |
| 270 | Blanton Duncan estate. | do | F-9 | | Bored, 8½-inch | 110 | 26 | 154 | | do | | | do | | |
| 271 | S. C. Smith | do | F-10 | 1902 | Bored, 7-inch | 30 | | 116 | 43 | Gas | 165.00 | | do | | |
| 272 | Hermosa Beach Water Co. | do | F-10 | | Bored | 25 | 0 | 200 | | | | | Not used | | |
| 273 | do | do | F-10 | 1902 | do | 25 | 0 | 140 | 230+ | Gas | | | | | |
| 274 | Israel Fry | do | F-10 | 1902 | Bored, 7-inch | 167 | 74 | 150 | 55 | Wind | | | Domestic | | |
| 275 | Venable & Claghorn | do | F-10 | | do | 175 | 89 | 176 | 42 | do | 200.00 | 100.00 | Domestic; stock | | |
| 276 | W. J. Edwards | San Pedro | G-11 | 1900 | Bored, 5-inch | 58 | | 70 | 53 | do | 70.00 | 75.00 | do | | |
| 277 | C. A. Edwards | do | G-8 | | Bored, 7-inch | 95 | 14 | 240 | 57 | do | | | do | | |
| 278 | Ed Vail | do | H-8 | 1898 | do | 75 | 15 | 147 | 49 | do | 165.00 | 75.00 | do | | |
| 279 | Mrs. Sarvent | Sausal Redondo | H-8 | 1883? | Dug, 4 by 4 foot. | 80 | 17 | 70 | 230+ | do | 70.00 | 50.00 | Stock | | |
| 280 | W. C. Miles | do | H-7 | 1895 | Bored, 7-inch | 90 | 38 | 227 | 35 | do | 325.00 | 175.00 | Domestic | | |
| 281 | C. A. Edwards | do | H-7 | 1902 | Bored, 10-inch | 85 | 25 | 199 | 38 | Gas | | | Domestic; irrigation. | | |
| 282 | Post & Lockhart | Sec. 22, T. 3 S., R. 14 W. | J-8 | 1899 | Bored, 4-inch | 60 | 32 | 154 | 43 | Wind | | | Domestic; stock | | |
| 283 | do | do | J-8 | | Dug, 3 by 3 foot. | 60 | 32 | 35 | 42 | do | | 75.00 | do | | |
| 284 | Stanley Bates | do | J-8 | 1903 | Bored, 10-inch | 62 | 27 | | 104 | | | | | | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 285 | W. G. Summers | Sec. 27, T. 3 S., R. 14 W. | J-8 | 1893 | Bored, 7-inch | 60 | 30 | 171 | 60 | Wind | $200.00 | $50.00 | Domestic | |
| 286 | E. Long | Sec. 26, T. 3 S., R. 14 W. | J-8 | 1901 | Bored, 10-inch | 61 | 28 | 38 | | do | 35.00 | 75.00 | do | |
| 287 | J. V. Ford | San Pedro | I-9 | 1902 | Bored, 7-inch | 100 | 10 | 149 | 26 | do | 175.00 | 75.00 | do | |
| 288 | Herman Geissler | do | I-9 | 1903 | Bored, 10-inch | | | | | | | | | |
| 289 | Walter Vail | Sausal Redondo | H-8 | 1899 | Bored, 7-inch | 73 | 24 | 125 | 37 | Wind | 135.00 | 65.00 | Stock | |
| 290 | do | do | H-9 | | do | 90 | 23 | 127 | 55 | do | 135.00 | 75.00 | Domestic | |
| 291 | J. G. McMorty | Sec. 27, T. 3 S., R. 14 W. | J-9 | 1888? | Dug, 5 by 5 foot. | 50 | 30 | 25 | 28 | Hand | | | do | |
| 292 | C. R. Davis | San Pedro | J-9 | 1903 | Bored, 7-inch | 48 | 21 | 238 | | Gas | 307.00 | | Domestic; irrigation. | |
| 293 | T. O. Dwight | do | J-9 | 1899 | do | 46 | 21 | 208 | 43 | Steam | | | Irrigation | 60 |
| 294 | N. Packard | do | K-9 | 1897 | do | 48 | 20 | 215 | 45 | do | 300.00 | 300.00 | do | |
| 295 | H. J. Harris | Sec. 26, T. 3 S., R. 14 W. | K-8 | 1902 | Bored | 55 | 27 | 205 | 92 | Wind | | | | |
| 296 | M. G. Rogers | Sec. 23, T. 3 S., R. 14 W. | J-8 | | do | | | | | Gas | | | Irrigation | |
| 297 | do | do | J-8 | | Bored, 8-inch | 75 | | | | | | | Not completed | |
| 298 | W. C. Smith | do | K-8 | | Dug, 3 by 3 foot. | 56 | 26 | 35 | 220 | Wind | | | Domestic | |
| 299 | C. W. Constable | do | K-8 | 1901 | Bored, 7-inch | 55 | 27 | 53 | 230+ | do | | | do | |
| 300 | W. F. Pope | San Pedro | K-8 | 1901 | Bored, 9½-inch | 55 | 23 | 217 | 54 | Gas | | | Irrigation | |
| 301 | do | do | K-8 | 1897 | Hydraulic, 2-inch. | 55 | 103 | 190 | 54 | Wind | | 65.00 | Domestic | |
| 302 | H. J. Bleay | Sec. 26, T. 3 S., R. 14 W. | K-8 | 1902 | Bored, 10-inch | 55 | 23 | 36 | 134 | do | | | Stock | |
| 303 | H. G. Harris | do | K-8 | | Bored | 55 | 23 | 226 | 45 | Gas | | 1,800.00 | Irrigation | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 304 | Arthur Hyon | Sec. 23, T. 3 S., R. 14 W. | K-8 | 1902 | Bored, 7-inch | 54 | 24 | 215 | 43 | Compressed air | 282.75 | | do | |
| 305 | H. C. Feder | San Pedro | E-11 | 1893 | do | 60 | 0 | 112 | 38 | Wind | 128.00 | 100.00 | Domestic | |
| 306 | do | do | G-11 | 1902 | Bored, 10-inch | 90 | 0 | 223 | 36 | Gas | 346.00 | | Irrigation | †5 |
| 307 | Mrs. John F. Francis | do | H-10 | 1893 | Bored, 7-inch | 90 | 11 | 175 | 42 | Wind | 200.00 | 125.00 | Domestic | |
| 308 | Redondo Cemetery | do | H-10 | 1903 | do | 125 | 15 | 199 | 35 | do | 350.00 | 65.00 | Irrigation | |
| 309 | Redondo Electric Rwy | do | H-10 | 1902 | Bored, 12-inch | 91 | | 280 | 39 | Electricity | | | Cooling machinery. | |
| 310 | W. D. Hammond | do | H-10 | 1902 | Bored, 7-inch | 100 | 2 | 190 | 45 | Wind | 224.00 | 75.00 | Domestic | |
| 311 | Mrs. Allen Loomis | do | I-10 | 1888 | do | 90 | 1 | 140 | 41 | do | 160.00 | | do | |
| 312 | Geo. Harsh | do | I-10 | 1895 | do | 91 | 1 | 174 | 43 | do | | | do | |
| 313 | A. Rochleau | do | I-10 | | Bored, 10-inch | 90 | 4 | 233 | 43 | Gas | 375.00 | | Irrigation; domestic. | |
| 314 | Paul Wandtke | do | I-9 | | Bored, 7-inch | 86 | 1 | 169 | 42 | Wind | | | Domestic | |
| 315 | W. S. Fullerton | do | I-9 | | do | 84 | 1 | 150 | 41 | do | 175.00 | | do | |
| 316 | Carl Schalk | do | I-9 | 1888 | do | 100 | 17 | 179 | 41 | do | 200.00 | 75.00 | do | |
| 317 | W. Sealey | do | I-9 | 1893 | Bored, 6-inch | 76 | 4 | 108 | 32 | do | 125.00 | 75.00 | do | |
| 318 | W. S. Fullerton | do | I-10 | | Bored | 92 | | | | Gas | | | Irrigation | |
| 319 | J. Rochleau | do | I-10 | 1902 | Bored, 10-inch | 93 | 28 | 230 | 30 | do | | | do | 12 |
| 320 | Guy Loomis | do | I-10 | 1903 | do | 92 | 27 | 250 | | do | | | do | 15 |
| 321 | R. O. Hickman | do | I-10 | 1902 | do | 87 | 22 | 230 | | Not installed | 450.00 | | | |
| 322 | Mr. Scott | do | I-10 | | Bored, 7-inch | 95 | 25 | 120 | 46 | Wind | 135.00 | 50.00 | Domestic | |
| 323 | do | do | H-10 | | do | 150 | 14 | 190 | 32 | do | | 65.00 | do | |
| 324 | T. Biggart | do | J-9 | 1903 | Bored, 4-inch | 69 | 29 | 237 | 34 | Gas | 350.00 | | Domestic; stock | |
| 325 | John Schroeder | do | J-9 | 1903 | Bored, 7-inch | 60 | 23 | 230 | 173 | Hand | 290.00 | | Domestic | |
| 326 | Mrs. Elizabeth Goss | do | J-9 | 1901 | do | 60 | 21 | 218 | 38 | Wind | | | do | |
| 327 | C. Raphael | do | J-9 | 1902 | Bored, 10-inch | 60 | 21 | 236 | 33 | | 300.00 | | Not used | |
| 328 | do | do | J-9 | 1902 | Bored, 7-inch | 60 | 21 | 230 | 33 | Compressed air | 300.00 | 2,600.00 | Irrigation | 56 |
| 329 | Mrs. Isabel Frayer | do | K-9 | 1896 | do | 57 | 28 | 255 | 35 | Gas | 350.00 | 1,100.00 | do | |
| 331 | J. Bixby | Los Palos Verdes | G-14 | | Bored, 8-inch | 200? | 68? | 600 | 173 | do | 10,000.00 | | Stock | |
| 332 | C. H. Quandt | do | H-12,13 | | Bored, 7-inch | 100 | 35 | 80 | 46 | Wind | | | do | |
| 333 | do | do | H-12,13 | | do | 100 | 35 | 80 | 38 | Gas | | | Stock; domestic | |
| 334 | Doctor Lind estate | do | H-13 | 1885 | Bored, 8-inch | 100 | 30 | 100 | 48 | Wind | 150.00 | 60.00 | do | |
| 335 | P. S. Venable | do | I-14 | 1888 | Bored, 7-inch | 100 | | 100 | | do | | | | |
| 336 | R. S. Venable | do | I-14 | 1898 | do | 140 | 25 | 235 | 77 | do | 365.00 | 100.00 | Domestic; stock | |
| 337 | B. S. Weston | do | I-13 | 1892 | do | 100 | 35 | 252 | 42 | do | 500.00 | 100.00 | Stock; domestic | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 338 | B. S. Weston | Los Palos Verdes. | I-15 | 1892 | Bored, 7-inch | 165 | 30 | 175 | 77 | Wind, gas | $375.00 | $125.00 | Domestic | |
| 339 | do | do | I-15 | 1901 | do | 165 | 30 | 470 | 77 | Gas | 900.00 | 410.00 | do | †4 |
| 340 | do | do | J-13 | 1898 | do | 100 | 35 | 223 | 42 | Wind | 511.00 | 100.00 | do | |
| 341 | do | do | J-14 | 1892 | Bored, 5-inch | 100 | 35 | 170 | 43 | do | 350.00 | 100.00 | Domestic; stock | |
| 342 | Mrs. Means | do | I-13 | 1895 | Bored, 7-inch | 100 | 30 | 189 | | Gas | 210.00 | 160.00 | Stock | 5 |
| 343 | Mrs. Minnie Leich | do | I-13 | 1896 | do | 100 | 30 | 175 | 38 | Wind | 203.00 | 100.00 | Domestic; stock | 2½ |
| 344 | H. J. McNally | do | I-13 | 1889 | do | 110 | 27 | 113 | | do | | | Not used | |
| 345 | do | do | I-13 | 1901 | do | 105 | 29 | 265 | 35 | Gas | 384.00 | 775.00 | Stock; domestic; irrigation. | 35 |
| 346 | G. W. Vaness | do | I-13 | 1889 | do | 100 | 30 | 114 | 44 | Wind | 120.00 | 75.00 | Stock; domestic | |
| 347 | Doctor De Lamo | San Pedro | I-12 | 1892 | do | 110 | 35 | 275 | 36 | do | | 100.00 | Domestic; stock | |
| 348 | E. Keffler | Los Palos Verdes. | K-13 | 1889 | do | 100 | 49 | 78 | 73 | do | | 75.00 | Stock | |
| 349 | G. A. March | San Pedro | K-13 | 1888 | Bored, 6-inch | 90 | 50 | 105 | 61 | do | 110.00 | 55.00 | Domestic; stock | |
| 350 | Joseph Lucas | do | K-13 | | Bored, 7-inch | 90 | 40 | 80 | 58 | do | | | Domestic | |
| 351 | Fred Bluemle | do | L-13 | 1897 | do | 80 | 42 | 290 | 26 | do | 433.00 | 100.00 | Domestic; stock | |
| 353 | Oliver McCoy | Los Palos Verdes. | L-14 | 1901 | Bored, 10-inch | 75 | 36 | 285 | 25 | do | 400.00 | 125.00 | Stock; domestic | |
| 354 | H. Dumke | do | L-14 | 1901 | Bored, 7-inch | 75 | | 388 | 34 | do | 425.00 | 75.00 | | |
| 355 | Mr. Nearbaum | do | K-14 | | do | 80 | | 400† | 32 | do | | | Stock | |
| 356 | F. West | San Pedro | M-14 | 1900 | Dug, 4 by 4 foot. | 50 | 48 | 5 | 61 | Hand | | | do | |
| 357 | Baptiste Lave | do | M-13 | | Bored, 7-inch | 50 | 23 | 35 | 102 | Wind | | | Stock; domestic | |
| 358 | Mrs. Jargins | Los Palos Verdes. | L-14 | 1888 | do | 65 | | 450 | 26 | do | | 60.00 | do | |
| 360 | Palos Verdes Winery | do | L-14 | 1884 | Dug, 3-foot diameter. | 50 | 32 | 25 | 195 | do | | | Irrigation; winery | |
| 361 | do | do | L-14 | 1895 | Dug, 4-foot diameter. | 65 | 34 | 49 | 193 | do | 50.00 | 75.00 | Winery | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 363 | Oscar McCoy | do | M-15 | 1897 | Dug, 4 by 4 foot. | 30 | 11 | 26 | 67 | do | 50.00 | 100.00 | Stock; domestic; irrigation. | |
| 364 | Andrew Hobland | do | L, M-15 | 1902 | do | 30 | 11 | 46 | 91 | do | | 75.00 | Not used | |
| 365 | Geo. Jorgenson | do | L-15 | 1898 | Dug, 2 by 4 foot. | 25 | 19 | 18 | 71 | Hand | | | Domestic; stock | |
| 366 | Neil Khirkaby | do | L-15 | 1899 | Dug, 4 by 4 foot. | 25 | 8 | 25 | 61 | Wind | | 40.00 | Domestic | |
| 367 | Geo. Bixby | do | L-16 | 1902 | Dug, 3 by 8 foot. | 25 | 23 | 7 | | do | 150.00 | | Stock | |
| 368 | do | do | L-15 | 1900 | Dug, 4 by 4 foot. | 50? | 36 | 16 | 55 | do | 35.00 | 65.00 | Domestic; stock | |
| 369 | Mr. Nearbaum | do | J-15 | 1895 | Bored, 7-inch | 175 | | 122 | | Not raised | | | Not used | |
| 370 | Mr. Burkhardt | do | L-17 | | Bored, 10-inch | 40 | 10 | 300? | 145 | Wind | | | Domestic; stock | |
| 371 | do | do | L-17 | | Bored, 7-inch | 25 | 25 | | 161 | Artesian | | | Stock | |
| 372 | Roman Sepulveda | do | L-17 | | Dug, 25-foot diameter.? | 25 | 12 | 16 | 81 | Steam | | | Domestic | |
| 373 | do | do | L-17 | 1900 | Dug, 17-foot diameter.? | 25 | 12 | 16 | 86 | do | | | do | †9 |
| 374 | do | do | L-17 | 1901 | do | 20 | 12 | 10 | 65 | do | | | do | |
| 375 | do | do | L-17 | 1902 | Dug, 10-foot diameter. | 25 | 15 | 13 | 67 | do | | | do | |
| 376 | J. W. Sepulveda | do | L-17 | | do | 20 | | | 75 | | | | | |
| 377 | W. O Sepulveda | do | L-17 | 1897 | Dug, 4 by 4 foot. | 20 | 10 | 12 | 230+ | Hand | 30.00 | | Fire | |
| 379 | De Lamo & Humphrey | San Pedro | K-11 | 1885 | Dug, 3½ by 3½ foot. | 50 | 13 | 37 | 140 | Wind | | | Domestic; stock | |
| 381 | J. H. Adelmeyer | do | K-10 | 1891 | Dug, 4-foot diameter, 40 feet; bored, 7-inch, 25 feet. | 60 | 20 | 65 | 75 | do | | 100.00 | Domestic | |
| 382 | J. A. Cameron | do | K-10 | 1902 | Bored, 12-inch | 60 | 30 | 45 | 81 | Hand | 22.00 | 45.00 | Domestic; stock | |
| 383 | Mr. Gilmore | do | K-10 | 1902 | do | 60 | 18 | 48 | | Wind | 24.00 | | Domestic | |
| 384 | Mrs. F. A. Corwin | do | K-10 | 1903 | Hydraulic, 4-inch. | 55 | 19 | 163 | 28 | Hand | 125.00 | 25.00 | Domestic; stock | |
| 385 | G. E. Brooks | do | K-10 | 1902 | Bored, 12-inch | 60 | 23 | 45 | 65 | do | 22.50 | 15.00 | do | |
| 386 | Moneta Water Co. | do | K-10 | | Dug, 8 by 8 foot. | 60 | 15 | 500 | 33 | Steam | | 185.00 | Irrigation | †50 |
| 387 | do | do | K-10 | | Dug, 8 by 8 foot, 45 feet; bored balance. | 60 | 15 | 200 | 33 | do | | | do | †50 |
| 388 | do | do | K-10 | | do | 60 | 15 | 200 | 33 | do | | | do | †50 |
| 389 | C. W. Stephenson | do | J-10 | 1903 | Bored, 10-inch | 65 | 23 | 52 | 145 | Hand | 27.00 | 23.00 | Domestic | |
| 390 | J. M. Dunn | do | J-10 | 1901 | Bored, 8-inch | 65 | 20 | 209 | 34 | Gas | 275.00 | 860.00 | Domestic; irrigation. | †50 |
| 391 | J. L. Dunn | do | K-9 | 1900 | Dug, 5 by 5 foot. | 58 | 34 | 29 | 25 | Wind | 30.00 | 25.00 | Domestic | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 392 | F. E. Sanders | San Pedro | K-10 | 1903 | Bored, 12-inch | 60 | 22 | 55 | 120 | Hand | $27.50 | $15.00 | Domestic | |
| 393 | T. Holloway | do | K-10 | 1903 | do | 60 | 25 | 40 | 230+ | Wind | 20.00 | 40.00 | Domestic; stock | |
| 394 | Mrs. Lucy F. Richardson. | do | K-10 | 1903 | do | 55 | 23 | 43 | 193 | do | 21.00 | | Domestic | |
| 395 | J. T. Blackburn | do | K-10 | 1903 | do | 55 | 25 | 42 | 156 | Hand | 21.00 | | do | |
| 396 | H. A. Johnson | do | K-9 | 1875 | Bored, 7-inch | 45 | 37 | 185 | 35 | do | 225.00 | | Domestic; stock | |
| 397 | do | do | K-9 | | Bored, 12-inch | 55 | 20 | 214 | | Gas | 257.00 | | Irrigation | †125 |
| 398 | M. B. Bynum | do | K-9 | 1903 | Bored, 10-inch | 70 | 50 | 35 | 30 | Wind | 12.25 | 20.00 | Stock | |
| 399 | F. H. Fraser | do | K-9 | 1903 | Bored, 12-inch | 25 | 13 | 26 | 230+ | do | 13.00 | | Domestic; stock | |
| 400 | B. A. Moore | do | K-9 | 1898 | Hydraulic, 4-inch, 40 feet; 2-inch, 105 feet. | 30 | 10 | 145 | 24 | Hand | 90.00 | 7.00 | Stock | |
| 401 | do | do | K-9 | 1900 | Bored, 12-inch | 35 | 15 | 31 | 117 | do | | 7.00 | do | |
| 402 | J. T. Limville | do | K-9 | 1896 | | 35 | 15 | 150 | 33 | Wind | 75.00 | | Domestic; irrigation; stock. | |
| 403 | R. Mikkelson | do | K-9 | 1898 | Bored, 7-inch | 35 | 17 | 170 | 37 | Wind, gas | 170.00 | 250.00 | Domestic; irrigation. | †35 |
| 404 | do | do | K-9 | | Dug, 4 by 4 foot. | 35 | 17 | 40 | 106 | Hand | | | Stock | |
| 405 | P. D. Armstrong | do | K-9 | 1894 | Bored, 7-inch | 35 | 15 | 190 | 36 | Gas | | 450.00 | Domestic; irrigation. | |
| 406 | A. B. Caldwell | do | K-9 | 1897 | do | 35 | 15 | 163 | 36 | Wind | 200.00 | 60.00 | Domestic; stock | |
| 407 | Fred Hant | do | K-9 | | Bored, 12-inch | 40 | 18 | 38 | 20 | do | | | Domestic | |
| 408 | A. B. Caldwell | do | K-9 | 1900 | Bored, 7-inch | 40 | 20 | 206 | 33 | Gas | 300.00 | 700.00 | Irrigation | †30 |
| 409 | Chas. Webb | do | K-9 | 1901 | do | 40 | 20 | 200 | 37 | Wind | 250.00 | 60.60 | Domestic; irrigation; stock. | |
| 410 | R. H. Hudson | do | K-9 | 1902 | Bored, 10-inch | 40 | 21 | 26 | 230+ | do | 13.00 | | Domestic; stock | |
| 411 | Mr. Pine | do | K-9 | 1903 | Bored, 12-inch | 40 | 22 | 25 | 169 | Hand | 12.00 | | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 412 | W. S. Meyers | do | K-9 | | Bored, 7-inch | 40 | 21 | 224 | 43 | Gas | | 725.00 | Domestic; irrigation. | †75 |
| 413 | Monita Canning Co. | do | K-9 | 1898 | do | 45 | 14 | 224 | 34 | Steam | | | Cannery | †150 |
| 414 | T. Cooper | do | K-9 | 1903 | Bored, 12-inch | 32 | 20 | 25 | 230+ | Hand | 13.00 | | Stock | |
| 415 | do | do | K-9 | 1901 | do | 40 | 20 | 36 | 230+ | Wind | 18.00 | 16.00 | Irrigation; stock | |
| 416 | Monita school district | do | K-9 | 1896 | Bored, 4-inch | 48 | | | 34 | do | | | Domestic | |
| 417 | W. H. Martin | do | K-9 | 1903 | Dug, 4 by 4 foot. | 45 | 21 | 26 | 230+ | Gas | 150.00 | 50.00 | Stock | |
| 418 | T. O. Dwight | do | K-9 | | do | 45 | 19 | 27 | 230+ | Hand | | | Not used | |
| 419 | G. A. King | do | J-9 | 1902 | Dug, 3 by 3 foot. | 45 | 27 | 20 | 230+ | do | 10.00 | | Domestic | |
| 420 | W. A. Cameron | do | J-9 | 1892 | Dug, 3½ by 3½ foot. | 55 | 33 | 25 | 230+ | do | 25.00 | 5.00 | Stock | |
| 421 | M. W. Raibley | do | K-9 | 1902 | Bored, 7-inch | 45 | 23 | 108 | 61 | Wind | 235.00 | 60.00 | Domestic; stock | |
| 422 | Geo. H. Watkinson | do | K-9 | 1901 | Bored, 12-inch | 50 | 34 | 26 | 230+ | Hand | 13.00 | 10.00 | do | |
| 423 | C. F. Bayha | do | K-9 | 1902 | do | 55 | 18 | 40 | 230+ | Wind | 20.00 | 35.00 | Irrigation; stock | |
| 424 | H. P. Palmer | do | K-9 | 1893 | Dug, 5-foot diameter. | 55 | 25 | 32 | 57 | Hand | | | Stock | |
| 425 | A. A. Whaley | do | K-9 | | Bored, 12-inch | 45 | 17 | 40 | 145 | Wind | | 125.00 | Domestic | |
| 426 | do | do | K-9 | 1895 | Dug, 4 by 4 foot. | 50 | 25 | 26 | 127 | Hand | | | Not used | |
| 427 | R. H. Diltz | do | K-9 | 1900 | Bored, 12-inch | 50 | 29 | 28 | 123 | Wind | 16.00 | 60.00 | Domestic; stock | |
| 428 | M. T. Sprague | do | K-9 | 1901 | do | 55 | 33 | 38 | 119 | do | | | Domestic; irrigation; stock. | |
| 429 | J. D. Beard | do | K-9 | 1902 | Bored, 7-inch | 55 | 25 | 134 | 111 | do | 140.00 | 200.00 | Domestic; irrigation. | |
| 430 | Mr. Champaign | do | K-9 | 1900 | Bored, 12-inch | 55 | 35 | 37 | 168 | do | 17.00 | 17.00 | Not used | |
| 431 | Chas. Stebbins | do | K-9 | 1895 | Dug, 5-foot diameter. | 53 | 32 | 26 | 104 | do | | | Domestic; stock | |
| 432 | H. Terrel | do | K-8 | 1902 | Dug | 53 | 32 | 25 | 115 | Hand | 25.00 | 2.50 | do | |
| 433 | W. J. Lembke | do | K-8 | 1903 | Bored, 4-inch | 54 | 32 | 173 | 34 | Wind | 138.40 | 46.50 | Stock | |
| 434 | Chas. Winberner | do | K-8 | | do | 55 | | 180 | | | | | | |
| 435 | Max Manty | do | K-8 | 1901 | Bored, 12-inch | 60 | 38 | 40 | 168 | Wind | 30.00 | 60.00 | Domestic; stock | |
| 436 | B. T. Hayden | do | K-9 | 1896 | Dug, 3½ by 3½ foot. | 50 | 29 | 25 | 173 | Hand | 25.00 | | Not used | |
| 437 | A. W. Dickenson | Sec. 23, T. 3 S., R. 14 W. | K-8 | 1899 | Bored, 8-inch | 60 | 25 | 230 | 46 | Gas | 250.00 | 825.00 | Irrigation | †90 |
| 438 | Jean Lagier | Sec. 24, T. 3 S., R. 14 W. | K-8 | 1898 | Bored, 7-inch | 60 | | 147 | 42 | Wind | | | Domestic; irrigation; stock. | |
| 439 | Mr. Roberts | Sec. 23, T. 3 S., R. 14 W. | K-8 | 1899 | Dug, 4 by 4 foot. | 60 | 27 | 36 | 173 | do | | | Domestic; stock | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 440 | O. S. Gorham | Sec. 24, T. 3 S., R. 14 W. | K-8 | 1893 | Dug, 4 by 4 foot. | 60 | 33 | 30 | 38 | Wind | | $60.00 | Domestic; stock | |
| 441 | do | do | K-8 | 1903 | Hydraulic, 4½-inch. | 60 | 30 | 355 | | Gas | $300.00 | 1,100.00 | Irrigation | †40 |
| 442 | Geo. O. Lampher | do | K-8 | 1902 | Bored, 10-inch | 60 | 30 | 43 | 102 | Hand | | | Domestic; stock | |
| 443 | J. T. Dunn | do | L-8 | 1901 | Bored, 8-inch | 60 | 28 | 207 | 86 | Compressed air | 275.00 | 1,400.00 | Irrigation | †80 |
| 444 | do | do | L-8 | 1883 | Dug, 3 by 3 foot. | 55 | 30 | 28 | 77 | Wind | 30.00 | 125.00 | Domestic | |
| 445 | do | do | L-8 | 1898 | Bored, 10-inch | 60 | 30 | 199 | 78 | Compressed air | 270.00 | | Stock | †10 |
| 446 | A. L. Beem | do | L-8 | 1888 | Bored, 4-inch | 65 | 30 | 140 | 46 | Wind | | | Domestic; stock | †5 |
| 447 | do | do | L-8 | 1897 | Bored, 7-inch | 65 | 30 | 206 | 46 | Steam | | | Irrigation | †65 |
| 448 | Mrs. Kate Drews | San Pedro | L-8 | 1893 | do | 60 | 27 | 218 | 88 | Gas | 250.00 | 900.00 | Domestic; irrigation. | †50 |
| 449 | R. J. Rogers | Sec. 24, T. 3 S., R. 14 W. | K-8 | 1901 | do | 60 | 30 | 197 | 46 | Compressed air | 280.00 | 1,050.00 | Domestic, irrigation; stock. | †60 |
| 450 | do | do | K-8 | 1896 | Hydraulic, 2½-inch. | 60 | 30 | 187 | | Not raised | 87.00 | | Not used | |
| 451 | G. N. Young | San Pedro | K-8 | 1903 | Bored, 6-inch | 60 | 30 | 205 | 40 | Hand | 180.00 | 12.00 | Domestic; stock | |
| 452 | John Osborne | do | L-8 | | Bored, 2-inch | 60 | 30 | 180 | 39 | Wind | | | do | |
| 453 | H. R. Parsons | do | L-8 | 1898 | Bored, 4-inch, 20 feet; bored, 2-inch, 158 feet. | 60 | 30 | 178 | 49 | do | 72.00 | 50.00 | do | |
| 454 | R. M. Klingensmith | do | K-8 | 1901 | Bored, 10-inch | 60 | 30 | 225 | 55 | Gas | 600.00 | 1,400.00 | Domestic; irrigation; stock. | †90 |
| 455 | H. E. Williams | do | K-8 | 1902 | do | 60 | 34 | 224 | 46 | do | 304.00 | 850.00 | Irrigation | |
| 456 | Tom Frost | do | K-8 | 1892 | Dug | 60 | 38 | 31 | 91 | Wind | | 60.00 | Domestic; irrigation; stock. | |
| 457 | H. T. Perley | do | L-8 | 1895 | Bored, 7-inch | 60 | 30 | 208 | 35 | do | 190.00 | 110.00 | Domestic; stock | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 458 | C. Sebelius | do | L-8 | 1901 | Bored, 10-inch | 55 | 28 | 240 | 37 | Compressed air | 491.00 | 1,050.00 | Domestic; irrigation. | †35 |
| 459 | Strawberry Park Water Co. | Sec. 24, T. 3 S., R. 14 W. | L-8 | 1903 | Bored, 12-inch | 60 | 28 | 250 | 182 | Gas | | | Irrigation | |
| 460 | do | do | L-8 | 1903 | do | 60 | 28 | 225 | 182 | do | | | do | |
| 461 | J. L. Griffin | San Pedro | L-8 | 1896 | Bored, 10-inch | 60 | 30 | 268 | 123 | Steam | 400.00 | 1,200.00 | Irrigation; stock | †125 |
| 462 | O. S. Graham | do | L-8 | 1898 | Bored, 7-inch | 55 | 33 | 200 | 91 | Gas | 238.00 | 550.00 | Irrigation | |
| 463 | Geo. M. Michell | do | L-8 | 1893 | do | 55 | 30 | 183 | 42 | Wind | 125.00 | 100.00 | Domestic; stock | |
| 464 | A. A. Cary | do | L-8 | 1903 | Hydraulic, 6-inch. | 50 | 30 | 194 | 33 | Gas | 193.00 | | Domestic; irrigation. | |
| 465 | W. M. Gray | do | L-8 | 1895 | Bored, 7-inch | 50 | 32 | 225 | 38 | do | 300.00 | 1,400.00 | do | |
| 466 | Los Angeles Company | do | L-9 | | do | 50 | 26 | 61 | 65 | Hand | | | Domestic | |
| 467 | J. H. McCartney | do | K, L-9 | 1902 | Bored, 6-inch | 50 | | | 36 | Wind | 90.00 | 75.00 | do | |
| 468 | Mr. Clark | do | K-8, 9 | | Bored, 8-inch | 52 | 26 | 177 | 50 | Hand | | | do | |
| 469 | E. M. Hicks | do | K-8 | 1896 | Dug, 5 by 5 foot. | 52 | 30 | 25 | 140 | Wind | | 65.00 | Stock | |
| 470 | J. A. Burns | do | K-8 | 1894 | Dug, 4 by 4 foot. | 52 | 31 | 24 | 150 | do | 26.00 | 65.00 | do | |
| 471 | John J. Dean | do | K-9 | 1902 | Bored, 10-inch | 50 | 30 | 249 | 36 | Wind, gas | 400.00 | 650.00 | Domestic; irrigation; stock. | †16 |
| 472 | B. T. Hayden | do | K-9 | 1893 | Bored, 12-inch | 52 | 32 | 25 | 120 | Wind | 20.00 | 40.00 | Domestic; stock | |
| 473 | F. W. Fitzpatrick | do | K-9 | 1900 | do | 52 | 29 | 30 | 144 | Hand | 15.00 | 5.00 | Stock | |
| 474 | W. N. Worrell | do | K-9 | 1903 | Bored, 7-inch | 50 | 25 | 236 | 50 | Gas | | 500.00 | Domestic; irrigation. | †15 |
| 475 | Will Kempson | do | K-9 | 1901 | Bored, 2-inch | 50 | 32 | | 140 | Hand | | | Domestic | |
| 476 | John Elsey | do | K-9 | 1897 | Dug, 4 by 4 foot. | 51 | 32 | 23 | 123 | Wind, hand | | 45.00 | Domestic; stock | |
| 477 | W. J. O'Brien | do | K-9 | 1901 | Bored, 12-inch | 49 | 27 | 35 | 135 | Hand | | | Domestic | |
| 478 | Geo. Burton | do | K-9 | 1898 | Dug, 4 by 4 foot. | 49 | 30 | 23 | 120 | do | | | do | |
| 479 | T. Stayton | do | K-9 | 1889 | Dug, 5-foot diameter. | 50 | 32 | 22 | 135 | Wind | 22.00 | 120.00 | Domestic; stock | |
| 480 | J. E. Longacre | do | K-9 | 1897 | Dug, 4 by 4 foot. | | | 24 | 137 | Hand | 25.00 | 3.00 | do | |
| 481 | Mrs. M. A. Wells | do | K-9 | 1895 | do | 45 | 26 | 22 | 128 | Wind | | 30.00 | Domestic; irrigation. | |
| 482 | O. W. Kendrick | do | K-9 | 1903 | Bored, 12-inch | 38 | 20 | 27 | 135 | do | 15.00 | 15.00 | Irrigation | |
| 483 | H. H. Luckensmeyer | do | K-9 | | do | 45 | 27 | 30 | | Hand | | | Not used | |
| 484 | Edward Larson | do | K-9 | 1903 | do | 50 | 32 | 30 | 173 | do | 15.00 | | Domestic | |
| 485 | H. A. Richards | do | K-9 | 1903 | Bored, 10-inch | 38 | 24 | 30 | 137 | Wind | | | do | |
| 486 | R. S. Moore | do | K-9 | 1902 | do | 38 | 20 | 40 | 120 | Hand | 20.00 | | do | |
| 487 | D. W. Jackson | do | K, L-9 | 1901 | do | 38 | 20 | 220 | 46 | Gas | | 675.00 | Irrigation | †70 |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 488 | W. McCune | San Pedro | L-9 | | Dug, 4 by 4 foot. | 38 | 20 | 22 | 173 | Wind | | | Stock | |
| 489 | Pedro Shapro | do | L-9 | 1898 | Bored, 4-inch | 38 | −2 | 110? | 41 | do | $200.00 | $50.00 | Domestic; stock | |
| 490 | A. N. Heffner | do | L-9 | 1900 | Bored, 4-inch, 40 feet; bored, 2-inch, 151 feet. | 38 | 21 | 191 | 34 | do | 100.00 | 170.00 | do | |
| 491 | J. A. Lakey | do | L-9 | 1898 | Bored, 7-inch | 38 | 20 | 235 | 60 | Steam | 325.00 | 1,300.00 | Irrigation | †90 |
| 492 | W. Bryant | do | L-9 | 1904 | | 43 | | | 42 | Gas | | | do | |
| 493 | C. E. Wallin | do | L-9 | 1895 | Bored, 4-inch | 43 | 30 | 28 | 83 | Wind | 75.00 | 105.00 | Stock | |
| 494 | Jessie Linkletter | do | L-9 | 1901 | do | 38 | 18 | 150 | 44 | do | 120.00 | 150.00 | Domestic | |
| 495 | L. Merrill | do | L-9 | 1898 | Dug | 38 | 24 | 18 | 106 | Hand | | | Domestic; stock | |
| 496 | N. E. Coweles | do | L-9 | 1902 | Bored, 7-inch | 38 | 22 | 205 | 37 | Gas | | 550.00 | Domestic; irrigation. | †45 |
| 497 | G. G. Glouner | do | M-9 | | Dug, 5-foot diameter. | 30 | 16 | 20 | 60 | Wind | | | Domestic; stock | |
| 498 | Geo. Bones | do | M-9 | | Bored, 7-inch | 38 | 20 | 200 | | do | 300.00 | 75.00 | Irrigation | |
| 499 | J. Edwin | do | M-9 | 1900 | Dug, 8 by 8 foot. | 32 | 16 | 35 | 92 | do | | | Domestic; stock | |
| 500 | do | do | M-9 | 1900 | Dug, 12 by 12 foot. | 32 | 16 | 37 | 73 | Wind, gas | | | Irrigation | 22 |
| 501 | Mrs. S. J. Barnum | do | M-9 | 1896 | Dug, 5 by 12 foot | 35 | 20 | 22 | 102 | Wind | | 75.00 | Domestic; stock | |
| 502 | Mrs. Alice Champlin | do | M-9 | | Dug, 4 by 6 foot. | 35 | 21 | 22 | 91 | do | | | Not used | |
| 503 | J. A James | do | M-9 | 1899 | Dug, 5 by 10 foot | 35 | 21 | 22 | 69 | do | | 100.00 | Domestic; irrigation; stock. | |
| 504 | H. Bristol | do | M-9 | 1898 | Dug, 4 by 4 foot. | 30 | 16 | 16 | 82 | do | | 65.00 | Domestic; irrigation. | |
| 505 | do | do | M-9 | 1900 | Dug, 4 by 6 foot. | 35 | 19 | 24 | 92 | do | 80.00 | | Irrigation | |
| 506 | do | do | M-9 | 1897 | Dug, 3 by 5 foot. | 35 | 20 | 18 | 91 | do | | | do | |
| 507 | W. L. Kellog | do | M-9 | 1903 | Dug, 4 by 6 foot. | 35 | 20 | 25 | 109 | Gas | 120.00 | 392.00 | do | †10 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 508 | Sam Jackson | do | M-9 | 1903 | Dug, 4 by 4 foot. | 35 | 17 | 31 | 92 | do | | 328.00 | Domestic; irrigation. |
| 509 | W. F. Calderwood | do | M-9 | 1892 | do | 30 | 17 | 14 | 104 | Hand | | | Not used |
| 510 | do | do | M-9 | 1897 | do | 30 | 18 | 17 | 92 | Wind | | | Domestic; stock |
| 511 | B. W. Barnes | do | M-9 | 1901 | Bored, 7-inch | 35 | 16 | 250 | 71 | do | | 140.00 | Domestic |
| 512 | Irving Baxter | do | M-9 | | Dug, 4 by 4 foot. | 30 | 14 | 22 | 91 | do | | | do |
| 513 | John H. Mackey | do | L-10 | 1902 | Dug | 25 | 7 | 28 | 79 | do | 35.00 | 165.00 | Domestic; stock |
| 515 | A. Schultz | do | L-10 | 1902 | Dug, 4 by 4 foot. | 20 | 1 | 38 | 57 | do | | | do |
| 516 | W. L. Kellog | do | M-9 | 1891 | Bored, 6-inch | 35 | 12 | 16 | 128 | Hand | | | Domestic |
| 517 | C. Houser | do | M-9 | | Bored, 5-inch | 35 | | 38 | 117 | Wind | | | Domestic; stock |
| 518 | R. Birt | do | M-9 | 1894 | Dug, 4 by 4 foot. | 30 | 16 | 23 | 109 | do | 75.00 | 114.00 | Domestic; irrigation; stock. |
| 519 | do | do | M-9 | 1893 | Bored, 7-inch | 38 | 24 | 210 | 106 | do | 400.00 | 80.00 | Irrigation |
| 520 | D. Cross | do | M-9 | | Dug, 4 by 4 foot. | 40 | | | 106 | Hand | | | Stock |
| 521 | Mr. Wickstrom | do | M-9 | | Dug | 35 | 21 | 15 | 101 | Wind | | | do |
| 522 | J. S. Youmans | do | M-9 | 1902 | Dug, 5 by 5 foot. | 30 | 9 | 25 | 115 | Gas | | 300.00 | Domestic; irrigation; stock. |
| 523 | John Blick | do | M-9 | 1900 | Dug, 8 by 10 foot | 35 | 23 | 15 | 96 | Wind, horsepower | | 190.00 | Domestic; stock |
| 524 | Mrs. Morris | do | M-9 | 1901 | Dug, 3-foot diameter, 7 feet; bored, 10-inch, 18 feet. | 30 | | 25 | 177 | Wind | | | Domestic |
| 525 | John M. Glass | do | M-10 | | Dug, 4 by 4 foot. | 30 | 13 | 22 | 103 | Wind, hand | | | Domestic; irrigation; stock. |
| 526 | do | do | M-10 | 1902 | Bored, 7-inch | 30 | 26 | 540 | | Not raised | 1,200.00 | | Not used |
| 527 | J. H. Bush | do | M-10 | 1903 | Bored, 12-inch | 30 | 16 | 30 | 127 | Hand | 10.00 | 5.00 | Domestic |
| 528 | E. A. Turner | do | M-10 | | Dug, 30-inch diameter. | 20 | 20 | 14 | 117 | Gas | 50.00 | 500.00 | Irrigation |
| 529 | do | do | M-10 | 1903 | Bored, 8-inch | 28 | 16 | 20 | 118 | Hand | 2.00 | 3.00 | Domestic |
| 530 | A. E. Elliott | do | M-10 | | Dug, 4 by 4 foot. | 28 | 13 | 19 | 103 | Wind | | | do |
| 531 | do | do | M-10 | | do | 28 | 17 | 21 | 96 | do | | | Stock |
| 532 | Chas. Turnbaugh | do | M-9 | 1903 | Bored, 2-inch | 30 | 20 | 25 | 78 | Hand | | | do |
| 533 | Geo. Stiman | do | M-9 | 1902 | Bored, 5-inch | 28 | | 60 | 75 | do | 23.00 | | Domestic |
| 534 | B. W. Barnes | do | M-9 | 1892 | Dug, 3 by 3 foot. | 30 | 15 | 18 | | Wind | 35.00 | 75.00 | Domestic; stock |
| 535 | do | do | M-9 | 1899 | Dug, 4 by 4 foot. | 30 | 9 | 27 | 130 | do | 50.00 | 120.00 | Irrigation |
| 536 | do | do | M-9 | 1895 | Dug, 4 by 5 foot. | 40 | 21 | 22 | 151 | do | 50.00 | 75.00 | do |
| 537 | D. Cross | do | M-9 | | Dug, 4 by 8 foot. | 35 | 18 | 17 | 150 | do | | | Not used |
| 538 | A. O. Whaley | do | M-9 | 1893 | Dug, 4 by 4 foot. | 40 | 25 | 20 | 144 | do | 55.00 | 100.00 | Domestic; stock |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 539 | G. H. Norton | San Pedro | M-9 | 1895 | Dug, 4 by 4 foot | 45 | 25 | 24 | 128 | Wind | $60.00 | $100.00 | Irrigation | ..... |
| 540 | ....do | ....do | M-9 | 1892 | ....do | 40 | 25 | 22 | 157 | Hand | 50.00 | 15.00 | Domestic | ..... |
| 541 | ....do | ....do | M-9 | 1893 | ....do | 45 | 27 | 22 | 177 | Wind | 60.00 | 100.00 | Irrigation | ..... |
| 542 | A. O. Whaley | ....do | M-9 | 1894 | ....do | 45 | 26 | 22 | 230+ | ....do | 55.00 | 75.00 | ....do | ..... |
| 543 | John Stalker | ....do | M-9 | ..... | ....do | 40 | 25 | 35 | 132 | ....do | ..... | ..... | Domestic | ..... |
| 544 | John Weber | ....do | M-9 | 1895 | Dug, 6 by 12 foot | 45 | 22 | 24 | 60 | Hand | ..... | 2.50 | Not used | ..... |
| 545 | R. D. Dow | ....do | M-8 | 1894 | Bored, 7-inch | 45 | 26 | 214 | 115 | Steam | 250.00 | 600.00 | Domestic; irrigation. | ..... |
| 546 | L. H. West | ....do | M-9 | 1882 | ....do | 45 | 21 | 223 | 104 | Gas | 400.00 | 800.00 | Domestic; irrigation; stock. | ..... |
| 547 | B. E. Jones | ....do | M-8 | 1899 | ....do | 45 | 15 | 227 | 40 | ....do | 370.00 | 1,050.00 | ....do | ..... |
| 548 | ....do | ....do | M-8 | 1893 | Dug, 5 by 5 foot | 45 | 25 | 28 | 167 | Wind | ..... | 75.00 | Domestic; stock | ..... |
| 549 | John Carden | ....do | M-8 | 1897 | Bored, 7-inch | 50 | 27 | 225 | 44 | Gas | 275.00 | 525.00 | Domestic; irrigation; stock. | ..... |
| 550 | C. N. Bassett | ....do | M-8 | ..... | ....do | 85 | 45 | 190 | 47 | Wind | 230.00 | ..... | Domestic; stock | ..... |
| 551 | A. B. Moore | ....do | M-8 | 1903 | Bored, 10-inch | 95 | 35 | 70 | 103 | ....do | 27.00 | 35.00 | ....do | ..... |
| 552 | Geo. Nichols | ....do | N-8 | ..... | Bored, 7-inch | 105 | ..... | ..... | 42 | ....do | ..... | ..... | ....do | ..... |
| 553 | C. N. Bassett | ....do | N-8 | 1902 | Bored, 10-inch | 100 | 75 | 190 | 41 | Gas | ..... | 1,700.00 | Irrigation | ..... |
| 554 | Gardena Water Co. | ....do | N-8 | 1900 | ....do | 85 | 75 | 184 | 43 | ....do | ..... | ..... | Domestic | ..... |
| 555 | ....do | ....do | N-8 | ..... | Bored, 7-inch | 85 | ..... | 184 | 42 | ....do | 200.00 | ..... | ....do | ..... |
| 556 | ....do | ....do | N-8 | ..... | ....do | 85 | ..... | ..... | 42 | ....do | ..... | ..... | ....do | ..... |
| 557 | ....do | ....do | N-8 | ..... | ....do | 85 | ..... | ..... | 42 | ....do | ..... | ..... | ....do | ..... |
| 558 | Duncan Co. | ....do | N-8 | 1897 | Bored, 9¾-inch | 80 | 75 | 196 | 39 | ....do | 300.00 | 1,600.00 | Irrigation | †130 |
| 561 | C. F. Rosecrans | Sec. 19, T. 3 S., R. 13 W. | L-7 | 1903 | Hydraulic, 6-inch. | 75 | 26 | 203 | 43 | Compressed air | 226.00 | 500.00 | ....do | ..... |
| 562 | ....do | ....do | L-7 | 1896 | Dug | 75 | 50 | 40 | 91 | ....do | ..... | ..... | Domestic | ..... |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 563 | Strawberry Park Land Co. | Sec. 13, T. 3 S., R. 14 W. | L-7 | 1887 | Dug, 6 by 6 foot. | 60 | 36 | 38 | 157 | do | 500.00 | | Domestic; stock | | |
| 564 | G. Nyberg | San Pedro | M-8 | | Bored, 7-inch | 70 | 40 | 240 | | do | 308.00 | | do | | |
| 565 | J. M. Low | do | M-8 | 1899? | Dug, 3 by 3 foot. | 55 | 39 | 17 | 126 | Hand | | | Domestic | | |
| 566 | Robert Westcott | do | M,N-8 | 1903 | Hydraulic, 4-inch, 60 feet; hydraulic, 2-inch, 110 feet. | 75 | 35 | 170 | 38 | Wind | 100.00 | 75.00 | Domestic; stock | | |
| 567 | J. M. Carter | do | N-9 | 1900 | Hydraulic, 3-inch. | 55 | 37 | 467 | 28 | do | | | do | | |
| 568 | do | do | N-9 | | Bored, 7-inch | 45 | 19 | 61 | 74 | do | 75.00 | | Stock | | |
| 569 | Mr. Thomas | do | M-9,10 | 1901 | Bored, 3-inch | 25 | 13 | 338 | 29 | do | | | Domestic; stock | | |
| 570 | do | do | M-9 | | Dug, 4 by 4 foot. | 25 | 21 | 6 | 157 | Hand | | | Not used | | |
| 571 | do | do | M-9 | 1903 | Bored, 5⅝-inch | 15 | 15 | 305 | 31 | Artesian | | | Stock | | |
| 572 | do | do | M-9 | | Dug, 6 by 6 foot. | 20 | 21 | 12 | 64 | Hand | | | Not used | | |
| 573 | John Commings | do | M,N-10 | | Bored, 7-inch | 50 | | | 33 | Wind | | | Stock | | |
| 574 | C. N. Haskins | do | N-8 | 1874 | do | 75 | 65 | 140 | 42 | do | | 165.00 | do | | |
| 575 | Mrs. F. Murphy | do | N-9 | 1899 | do | 75 | 63 | 350 | 33 | Gas | | 1,000.00 | Domestic; irrigation. | †40 | |
| 576 | do | do | N-9 | 1896 | Hydraulic, 2-inch. | 75 | 65 | 350 | | Not raised | | | Not used | | |
| 577 | do | do | N-9 | 1898 | Bored, 7-inch | 75 | 75 | 135 | | Hand | | | do | | |
| 578 | do | do | N-9 | 1891 | do | 75 | 75 | 190 | | Wind | | 125.00 | Stock | | |
| 579 | do | do | N-9 | 1903 | Hydraulic, 4-inch. | 75 | 71 | 111 | | Gas | 109.00 | | Domestic; stock | | |
| 580 | E. C. Haskins | do | N-8 | 1883 | Bored, 9½-inch | 75 | 53 | 154 | 44 | do | 250.00 | 900.00 | Irrigation | †75 | |
| 583 | W. R. Steele | do | N-8 | 1883 | Bored, 6-inch | 105 | 75 | 175 | 40 | Wind | | | Domestic; irrigation; stock. | | |
| 584 | P. Paradis | do | N-8 | | Dug, 3½ by 3½ foot. | 99 | 75 | 26 | 98 | do | | | Not used | | |
| 585 | J. E. Paradis | do | N-8 | 1880? | Bored, 7-inch | 99 | 82 | 188 | 40 | Gas | | 1,100.00 | Domestic; irrigation; stock. | †69 | |
| 586 | Enterprise school district. | do | N-8 | | do | 105 | | | 38 | Wind | | | Domestic | | |
| 587 | H. C. Kelsea | do | N-7 | 1880 | do | 100 | 85 | 198 | 44 | Gas | | 900.00 | Domestic; irrigation. | †40 | |
| 588 | Samuel Flick | do | N-7 | 1895 | do | 100 | 85 | 200 | 38 | Wind | | | Domestic; stock | | |
| 589 | Mrs. Minnie Lossing | do | N-7 | 1891 | do | 100 | 80 | 197 | 39 | Gas | | | Domestic; irrigation; stock. | | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 590 | P. Commeree | Tajanta | N-7 | 1899 | Bored, 7-inch | 90 | 80 | 200 | 36 | Gas | $200.00 | $700.00 | Irrigation | †40 |
| 591 | Wm. Falkner | do | N-7 | 1899 | Bored, 9½-inch | 90 | 80 | 250 | 37 | Gas, wind | 600.00 | 1,400.00 | Irrigation; stock | †150 |
| 592 | C. I. Falkner | do | N-7 | 1899 | Bored, 3-inch | 100 | 90 | 131 | 42 | Wind | 60.00 | 125.00 | Stock | |
| 593 | Mr. Sooner | Sec. 16, T. 3 S., R. 13 W. | N-7 | | Dug, 5 foot diameter. | 105 | 70 | 37 | 56 | do | | | Domestic | |
| 594 | J. Henninger | Sec. 17, T. 3 S., R. 13 W. | N-7 | 1903 | Bored 4-inch, 50 feet; bored, 2-inch, 86 feet. | 110 | 75 | 136 | 42 | do | 85.00 | 50.00 | Domestic; stock | |
| 595 | Edward Flick | do | N-7 | 1890 | Dug, 4-foot diameter. | 115 | 78 | 38 | 68 | do | 20.00 | 30.00 | do | |
| 596 | C. Hellum | do | N-7 | 1888 | Dug | 120 | 83 | 39 | 51 | do | | | do | |
| 597 | Shellenberger, Anderson & Park. | San Pedro | N-7 | 1899 | Bored, 10-inch | 107 | 70 | 193 | 41 | Gas | 280.00 | 815.00 | Domestic; irrigation. | †50 |
| 598 | Geo. Nichols | do | N-7 | | Dug, 4 by 4 foot | 120 | 80 | 58 | 39 | Not raised | | | Not used | |
| 599 | B. H. Muller | Sec. 17, T. 3 S., R. 14 W. | M-7 | 1897 | Bored, 6-inch | 120 | 90 | 160 | 38 | Gas | | | Domestic; stock | †5 |
| 600 | Geo. W. Gaines | do | M-7 | | do | 125 | | | 40 | Wind | | | do | |
| 601 | Edmund Locke | Sec. 18, T. 3 S., R. 14 W. | L-7 | 1901 | Bored, 7-inch | 100 | 35 | 250 | 38 | Gas | | 650.00 | Domestic; irrigation; stock. | |
| 602 | H. L. Gordon | San Pedro | M-8 | 1894? | Bored, 4-inch | 115 | 33 | 208 | 41 | do | | | Domestic; irrigation. | |
| 604 | G. R. Brown | Sec. 16, T. 3 S., R. 13 W. | N-7 | 1888 | Bored, 7-inch | 105 | | 196 | 40 | Wind | | | Domestic; stock | |
| 605 | Flick & Hellum | Sec. 17, T. 3 S., R. 13 W. | N-7 | 1894 | do | 115 | 80 | 198 | 41 | Gas | 300.00 | 600.00 | Irrigation; stock | †35 |
| 606 | G. D. Lee | Tajanta | N-7 | 1903 | Bored, 2-inch | 100 | 91 | 167 | 41 | Hand | 96.00 | 15.00 | Domestic; stock | |
| 607 | Alonzo Lee | do | N-7 | 1901 | do | 100 | | | 41 | Wind, hand | 100.00 | 145.00 | Domestic; irrigation; stock. | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 608 | A. Breckenridge | do | N-6 | | Bored, 7-inch | 100 | | | 43 | Hand | | | Domestic; stock | | |
| 609 | G. F. Brinkerhoff | do | N-6 | 1900 | Bored, 10-inch | 100 | 100 | 300 | | Not raised | 535.00 | | Not used | | |
| 610 | do | do | N-6 | 1895 | Dug, 4 by 4 foot. | 100 | 90 | 14 | 62 | Wind | | 100.00 | | | |
| 611 | A. L. Davenport | do | N-5 | 1892 | Bored, 2-inch | 105 | 105 | 300 | 38 | Artesian | | | Domestic; stock | | |
| 612 | Castruccio & Vala | Sec. 8, T. 3 S., R. 13 W. | N-5 | 1888 | Bored, 7-inch | 110 | 106 | 250 | 42 | Hand | | | Domestic | | |
| 613 | S. L. Wright | do | N-5 | 1894 | Bored, 9-inch (2) | 114 | 106 | 238 | | Gas | 1,200.00 | 1,000.00 | Irrigation | †40 | |
| 614 | do | do | N-5 | 1902 | Bored, 12-inch | 115 | 97 | 550 | 39 | do | 1,250.00 | 1,800.00 | Domestic; irrigation. | 117 | |
| 615 | do | Sec. 5, T. 3 S., R. 13 W. | N-5 | 1899 | Bored, 9-inch | 120 | 116 | 300 | 44 | do | 600.00 | 700.00 | Irrigation | †50 | |
| 616 | do | do | N-5 | 1900 | Hydraulic, 2-inch | 120 | 113 | 250 | 41 | Wind | 175.00 | 150.00 | Domestic | | |
| 617 | Mr. Glass | Sec. 8, T. 3 S., R. 13 W. | N-6 | 1901 | Bored, 12-inch | 115 | 98 | 500 | 45 | Gas | 1,250.00 | | Not used | | |
| 618 | N. Kirst | Sec. 32, T. 2 S., R. 13 W. | N-4 | 1902 | Bored, 10-inch | 125 | 114 | 550 | 46 | do | 1,120.00 | 1,250.00 | Irrigation | †100 | |
| 620 | S. Buckley | do | N-4 | 1899 | Bored, 12-inch | 125 | 116 | 100 | 56 | Wind | 100.00 | 150.00 | Domestic; stock | | |
| 621 | James S. Hart | do | N-4 | | Bored, 7-inch | 124 | | 70? | 54 | do | | | do | | |
| 622 | do | do | N-4 | 1883 | do | 124 | 120 | 148 | 29 | Not raised | | | Not used | | |
| 623 | T. T. Bradshaw | do | M-4 | | do | 130 | 112 | 90 | 52 | Hand | | | Domestic; stock | | |
| 624 | E. Yeldon | do | N-4 | 1902 | Bored, 3-inch | 130 | 115 | 30 | 158 | do | | | do | | |
| 625 | L. DeGroote | do | M-3,4 | 1888 | Bored, 7-inch | 130 | 110 | 100 | 50 | Wind | 100.00 | | Domestic | | |
| 626 | John Pearson | do | M-4 | 1895? | do | 130 | 120 | 87 | 55 | do | | 300.00 | Domestic; stock | | |
| 627 | E. H. Kincaid | do | M-4 | 1899 | Dug, 3 by 3 foot. | 130 | 120 | 18 | 51 | do | | | Domestic | | |
| 628 | Chas. McClain | Sec. 31, T. 2 S., R. 13 W. | M-4 | | do | 135 | 124 | 18 | 103 | Not raised | | | Not used | | |
| 629 | J. H. McGuire | Sec. 32, T. 2 S., R. 13 W. | M-4 | 1898 | Dug, 2-foot diameter. | 135 | 123 | 14 | 60 | Hand | 15.00 | | Domestic | | |
| 630 | Frank Rhodes | Sec. 31, T. 2 S., R. 13 W. | M-4 | 1895 | Dug, 2 by 4 foot. | 135 | 124 | 15 | 117 | Wind | | | Domestic; stock | | |
| 631 | O. A. Nelson | Sec. 29, T. 2 S., R. 13 W. | M-3 | | Hydraulic, 2-inch. | 135 | 122 | 112 | 40 | do | 52.00 | 130.00 | do | | |
| 632 | do | do | M-3 | 1904 | Bored, 14-inch | 135 | 123 | 93 | | | | | | | |
| 633 | Chas. Haddock | Sec. 32, T. 3 S., R. 13 W. | M-3 | 1891 | Bored, 7-inch | 135 | | 75 | 51 | Wind | | | Domestic; stock | | |
| 634 | do | do | M-3 | 1899 | Bored, 10-inch | 135 | 115 | 365 | | Not raised | | | Not used | | |
| 635 | M. D. McKee | do | M-4 | 1903 | Bored, 7-inch | 130 | 120 | 200 | 47 | Hand | 213.00 | 4.00 | Domestic; stock | | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 636 | M. D. McKee | Sec. 32, T. 3 S., R. 13 W. | M-4 | | Dug, 3 by 3 foot. | 130 | 120 | 13 | 74 | Not raised | | | Not used | |
| 637 | Harvey McClain | do | M-4 | 1889? | | 130 | 118 | 76 | 40 | Hand | | | Domestic; stock | |
| 638 | Lewis Fogle | Sec. 31, T. 2 S., R. 13 W. | M-4 | 1903 | Bored, 6-inch | 135 | 128 | 29 | 230+ | Wind | $26.00 | $50.00 | do | |
| 639 | do | do | M-4 | 1890 | Dug, 4 by 4 foot. | 140 | 128 | 14 | 103 | Not raised | | | Not used | |
| 640 | Mrs. N. S. Duncan | do | M-4 | 1903 | Bored, 7-inch | 140 | 122 | 227 | 54 | Wind | 300.00 | 124.00 | Domestic; stock | |
| 641 | do | do | M-4 | 1886 | Dug, 4-foot diameter. | 140 | 127 | 17 | 85 | do | | | Stock | |
| 642 | J. S. Duncan | do | M-4 | 1903 | Bored, 7-inch | 140 | 129 | 40 | 79 | do | 23.00 | 117.00 | Domestic; stock | |
| 643 | do | do | M-4 | 1886 | Dug, 4 by 4 foot. | 140 | 130 | 11 | 151 | Not raised | | | Not used | |
| 644 | H. Leiding | Sec. 32, T. 2 S., R. 13 W. | M-4 | 1901 | Bored, 4-inch | 135 | 118 | 42 | 68 | Hand | 40.00 | | Domestic; stock | |
| 645 | do | do | M-4 | | Bored, 5-inch | 135 | 113 | 16 | 94 | Not raised | | | Not used | |
| 646 | Chas. McClain | Sec. 31, T. 2 S., R. 13 W. | M-4 | 1902 | do | 135 | 118 | 42 | 76 | Wind | | | Stock | |
| 647 | Hurd Bros. Co. | Sec. 32, T. 2 S., R. 13 W. | M-3 | | Bored, 7-inch | 135 | | 70 | 59 | do | | | Domestic | |
| 648 | Thomas Quinn | do | M-3 | 1889 | do | 135 | 126 | 102 | 55 | do | 100.00 | 200.00 | Domestic; stock | |
| 649 | Fred Korgan | do | M-3 | 1884 | | | | | 55 | | | | | |
| 650 | T. C. Coakley | do | N-3 | 1899 | Bored, 2-inch | | | 40 | 59 | Hand | 80.00 | | Domestic | |
| 651 | Green Meadow school district. | Sec. 29, T. 2 S., R. 13 W. | N-3 | | do | 135 | | | 55 | Wind | | | do | |
| 652 | Mr. DeBroin | Sec. 32, T. 2 S., R. 13 W. | N-3 | 1883? | Bored, 7-inch | 135 | | | 55 | Hand | | | Domestic; stock | |
| 653 | do | do | N-3 | | do | 128 | 119 | 70 | 27 | Not raised | | | Not used | |
| 654 | F. W. Weeks | do | N-3 | 1877? | do | 128 | 118 | 87 | 55 | Wind | | | Domestic; stock | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 655 | F. M. Weeks | do | N-3 | 1883 | do | 128 | 118 | 106 | | Compressed air | | 1,100.00 | Irrigation | †60 |
| 656 | do | do | N-3 | 1880 | do | 130 | 120 | 114 | | do | | | do | |
| 657 | W. Cleland | Sec. 29, T. 2 S., R. 13 W. | N-3 | 1896 | Bored, 2-inch | 130 | 123 | 97 | 64 | Wind | 37.00 | 95.00 | Domestic; stock | |
| 658 | D. M. Durrell | Tajanta | N-3 | 1878? | Bored, 7-inch | 130 | 123 | 105 | 61 | do | | | do | |
| 659 | do | do | N-3 | 1886 | do | 130 | 123 | 83 | 27 | Not raised | | | Not used | |
| 660 | W. A. Hudson | do | N-3 | | do | 130 | 117 | 125 | 52 | Wind | | 100.00 | Domestic; stock | |
| 661 | do | do | N-3 | 1895 | do | 130 | 118 | 125 | | Gas | 130.00 | 1,500.00 | Irrigation | †60 |
| 662 | do | do | N-3 | 1903 | Bored, 10-inch | 130 | 118 | 123 | | do | 135.00 | | do | †65 |
| 663 | W. K. Clifford | do | N-3 | | Bored, 7-inch | 130 | 119 | 80 | 59 | Wind | 80.00 | 125.00 | Domestic; irrigation; stock. | |
| 664 | John Kilroy | Sec. 28, T. 2 S., R. 13 W. | N-3 | 1902 | Bored, 8-inch | 130 | 116 | 90 | 64 | Hand | 100.00 | 3.00 | Domestic; stock | |
| 665 | J. N. Stone | Tajanta | N-3 | | Bored, 7-inch | 130 | 121 | 105 | 66 | do | | | Domestic | |
| 666 | Mrs. Moyle | do | N-4 | | Bored, 2-inch | 124 | | | 56 | Wind | | | Domestic; stock | |
| 667 | S. W. Newell | do | N-4 | 1896 | do | 128 | | 78 | 56 | do | 35.00 | 75.00 | do | |
| 668 | do | do | N-4 | | Bored, 6-inch | 128 | | 73 | | Not raised | | | Not used | |
| 669 | Mr. Cromwell | do | N-4 | | Bored, 7-inch | 130 | | 65 | 56 | Hand | | | do | |
| 670 | W. S. Nay | do | N-4 | 1895? | do | 125 | 119 | 80 | 60 | Gas | | | Domestic | |
| 671 | do | do | N-4 | | do | 125 | 122 | 65 | 32 | Not raised | | | Not used | |
| 672 | Robert Graham | do | N-4 | | do | 120 | 115 | 180 | 31 | do | | | do | |
| 673 | do | do | N-4 | 1903 | do | 120 | 114 | 74 | 51 | Wind | 75.00 | 50.00 | Domestic; stock | |
| 674 | A. G. Williams | Sec. 32, T. 2 S., R. 13 W. | N-4 | | Bored | 120 | | | 38 | Hand | | | do | |
| 675 | Nicholas Kirst | Sec. 5, T. 3 S., R. 13 W. | N-4 | 1897 | Bored, 9½-inch | 120 | 111 | 300 | 42 | Wind | 550.00 | 100.00 | do | |
| 676 | do | do | N-4 | 1903 | Bored, 7-inch | 120 | 111 | 48 | 46 | Not raised | 40.00 | | Not used | |
| 677 | do | do | N-4 | 1903 | Dug, 4 by 4 foot | 120 | 111 | 17 | 54 | do | | | do | |
| 678 | Mr. Atlebury | Sec. 32, T. 2 S., R. 13 W. | M-4 | | Bored | 130 | | | 56 | Gas | | | Irrigation | |
| 680 | Mr. Wilcox | Sec. 6, T. 3 S., R. 13 W. | M-4 | | Bored, 4-inch | 140 | 120 | | 37 | Wind | | | Domestic; stock | |
| 682 | L. D. Doke | Sec. 5, T. 3 S., R. 13 W. | M-5 | 1895 | Dug | 135 | 110 | 40 | 42 | Hand | | 6.00 | do | |
| 683 | Joe Burkhardt | Sec. 6, T. 3 S., R. 13 W. | M-5 | 1890 | Bored, 7-inch | 150 | 115 | 160 | 41 | Wind | 170.00 | | do | |
| 684 | Geo. Meyers | Sec. 7, T. 3 S., R. 13 W. | M-5 | 1883 | do | 165 | 110 | 150 | 40 | do | | | Stock | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 685 | Geo. Bixby | Sec. 8, T. 3 S., R. 13 W. | M-6 | 1893 | Bored, 3-inch | 140 | | | 39 | Wind | | | Domestic; stock | |
| 686 | J. R. Haurvorth | Sec. 17, T. 3 S., R. 13 W. | M-6 | 1903 | Dug, 3 by 3 foot | 135 | 93 | 46 | 63 | do | $50.00 | $56.00 | do | |
| 687 | Fred Wolfgram | do | M-7 | 1893 | Bored, 7-inch | 130 | 90 | 207 | 40 | do | | *750.00 | do | |
| 688 | Max Jenney | Sec. 18, T. 3 S., R. 13 W. | L, M-7 | 1903 | Hydraulic, 6-inch. | 150 | 95 | 235 | 43 | Gas | 300.00 | 500.00 | Domestic; irrigation. | |
| 689 | William Williams | Sec. 7, T. 3 S., R. 13 W. | M-6 | 1884 | Bored, 7-inch | 190 | 120 | 159 | 42 | Wind | 300.00 | 90.00 | Domestic; irrigation; stock. | |
| 690 | Bixby & Hall | do | L-7 | | do | 175 | 39 | 157 | 42 | do | | 75.00 | Domestic; stock | |
| 691 | Geo. Bixby | do | L-6 | | do | 180 | 86 | | 92 | Not raised | | | Not used | |
| 692 | do | Sec. 13, T. 3 S., R. 14 W. | L-6 | 1888 | Bored | 135 | 75 | 250 | 44 | Wind | | | Domestic; stock | |
| 693 | Jothan Bixby | Sec. 12, T. 3 S., R. 14 W. | L-6 | 1891 | Driven, 3-inch | 205 | | 136 | 44 | do | | | Domestic | |
| 694 | Mrs. M. P. Hutchinson | do | L-7 | 1904 | Bored, 4-inch | 175 | 64 | 168 | 45 | do | 210.00 | 100.00 | Domestic; stock | |
| 695 | B. Kirst | do | L-6 | 1900 | Hydraulic, 2-inch. | 180 | 47 | 168 | 40 | do | 45.00 | | do | |
| 696 | C. H. Moser | do | L-6 | 1888 | Bored, 7-inch | 160 | 100 | 210 | 40 | do | | 75.00 | do | |
| 697 | Lawrence Fogle | do | K-6 | | Hydraulic, 3-inch. | 155 | 15 | 165 | 32 | do | 140.00 | 110.00 | Not used | |
| 698 | C. Bohm | do | K-6 | 1903 | Bored, 3-inch | 150 | 23 | 137 | 48 | do | 135.00 | 75.00 | Domestic; stock | |
| 699 | A. Kaeferstein | do | K-6 | 1891 | Bored, 7-inch | 170 | 56 | 196 | 44 | do | 315.00 | 75.00 | do | |
| 700 | J. B. Brockley | Sec. 1, T. 3 S., R. 13 W. | L-5 | 1884 | do | 185 | 91 | 120 | 44 | do | 130.00 | 120.00 | do | |
| 701 | C. Edgar Smith | Sec. 1, T. 3 S., R. 14 W. | L-4 | | do | 155 | 147 | 57 | 43 | do | | 80.00 | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 702 | .....do..... | .....do..... | L-5..... | 1895 | .....do..... | 180 | 108 | 150 | ..... | .....do..... | ..... | ..... | Not used..... | ..... |
| 703 | Chas. Haddock..... | Sec. 36, T. 2 S., R. 14 W. | L-4..... | 1880? | .....do..... | 155 | 70 | 175 | 40 | .....do..... | ..... | 75.00 | Domestic; stock. | ..... |
| 704 | .....do..... | .....do..... | L-4..... | ..... | .....do..... | 190 | 93 | 221 | 37 | .....do..... | ..... | ..... | Irrigation..... | ..... |
| 705 | .....do..... | .....do..... | L-4..... | 1894 | .....do..... | 190 | 100 | 222 | ..... | Gas..... | ..... | 625.00 | .....do..... | 5 |
| 706 | Jacob Rhenigana..... | Sec. 1, T. 3 S., R. 14 W. | L-5..... | 1885 | .....do..... | 222 | 80 | 146 | 38 | Wind..... | ..... | 80.00 | Stock..... | ..... |
| 707 | J. G. Howland..... | Sec. 31, T. 2 S., R. 13 W. | L-4..... | 1896 | .....do..... | 145 | 125 | 80 | 45 | .....do..... | 100.00 | ..... | Domestic; stock. | ..... |
| 708 | Mrs. Grace Adams..... | .....do..... | L-4..... | 1900 | .....do..... | 145 | 125 | 85 | 44 | .....do..... | ..... | 35.00 | .....do..... | ..... |
| 709 | Mrs. S. A. Howland..... | .....do..... | M-4..... | 1895 | .....do..... | 135 | 122 | 150 | 43 | .....do..... | ..... | 35.00 | .....do..... | ..... |
| 710 | .....do..... | .....do..... | M-10..... | 1900 | Bored, 10-inch.. | 135 | 123 | 255 | ..... | Gas..... | 750.00 | 3,250.00 | Irrigation..... | †85 |
| 711 | A. J. Howland..... | .....do..... | M-4..... | 1900 | Bored, 7-inch... | 140 | ..... | ..... | 43 | Wind..... | ..... | ..... | Domestic; stock. | ..... |
| 712 | Mr. Oninby..... | .....do..... | L-4..... | 1889? | Bored, 6-inch... | 140 | ..... | ..... | ..... | Not raised..... | ..... | ..... | Not used..... | ..... |
| 713 | Demmy Till..... | Sec. 36, T. 2 S., R. 14 W. | L-4..... | ..... | Bored, 7-inch... | 145 | 125 | 110 | 68 | Wind..... | ..... | ..... | Domestic; stock. | ..... |
| 714 | W. E. Hughes..... | .....do..... | L-4..... | 1896 | .....do..... | 175 | 100 | 275 | 39 | .....do..... | ..... | 40.00 | .....do..... | ..... |
| 715 | St. Michael School.... | Sec. 25, T. 2 S., R. 14 W. | L-3..... | ..... | .....do..... | 140 | ..... | ..... | 39 | Hand..... | ..... | ..... | Domestic..... | ..... |
| 716 | A. Stoll..... | Sec. 30, T. 2 S., R. 13 W. | L-3..... | ..... | .....do..... | 135 | 124 | 77 | 83 | Wind..... | ..... | ..... | Stock..... | ..... |
| 717 | Mrs. M. Gaines..... | .....do..... | M-3..... | 1879? | Dug, 3 by 3 foot. | 135 | 125 | 11 | 85 | Hand..... | ..... | ..... | Domestic; stock. | ..... |
| 719 | R. Orsi..... | Sec. 31, T. 2 S., R. 13 W. | M-3..... | 1889 | Bored, 7-inch... | 135 | 123 | 360 | 38 | Wind..... | 760.00 | 115.00 | ..... | ..... |
| 720 | T. A. McLain..... | Sec. 30, T. 2 S., R. 13 W. | M-3..... | 1903 | Bored, 5-inch... | 130 | 118 | 40 | 100 | .....do..... | 26.00 | 130.00 | Domestic..... | ..... |
| 721 | Mr. Egan..... | .....do..... | M-3..... | ..... | Bored, 12-inch.. | 130 | 119 | 107 | 38 | .....do..... | ..... | ..... | .....do..... | ..... |
| 722 | Andrew Hutflese..... | .....do..... | M-3..... | 1901 | Bored, 7-inch... | 130 | 118 | 83 | 52 | Hand..... | 91.00 | ..... | Domestic; stock. | ..... |
| 723 | Isaac Russell..... | .....do..... | M-3..... | ..... | .....do..... | 130 | 119 | 63 | ..... | Not raised..... | ..... | ..... | Not used..... | ..... |
| 724 | .....do..... | .....do..... | M-3..... | ..... | .....do..... | 130 | 118 | 42 | ..... | .....do..... | ..... | ..... | .....do..... | ..... |
| 725 | Wm. Neill..... | Sec. 29, T. 2 S., R. 13 W. | M-3..... | ..... | .....do..... | 130 | 119 | 91 | 54 | Wind..... | 91.00 | ..... | Domestic; stock. | ..... |
| 726 | Wm. Price..... | .....do..... | M-2..... | 1886 | .....do..... | 135 | 121 | 114 | 56 | Gas..... | 150.00 | 1,100.00 | Domestic; irrigation; stock. | ..... |
| 727 | Richard Montee..... | Sec. 30, T. 2 S., R. 13 W. | M-2..... | ..... | .....do..... | 130 | 118 | 115 | 54 | Wind..... | ..... | ..... | Domestic..... | ..... |
| 729 | Pachmayr Bros..... | .....do..... | M-3..... | 1900 | Bored, 9½-inch.. | 130 | 117 | 87 | 53 | Wind, gas..... | 150.00 | 400.00 | Domestic; irrigation; stock. | †40 |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 730 | H. Girer | Sec. 30, T. 2 S., R. 13 W. | M-3 | 1899 | Dug, 3½ by 3½ foot. | 130 | 119 | 15 | 44 | Hand | | | Domestic; stock. | |
| 732 | Mrs. Fanny Wethern | do | M-3 | 1903 | Bored, 7-inch | 130 | 113 | 186 | 42 | Wind | *$500.00 | | do | |
| 733 | Eliza Connelly | Sec. 25, T. 2 S., R. 14 W. | L-3 | | do | 140 | 121 | 108 | 45 | do | | | do | |
| 734 | do | do | L-3 | 1904 | Bored, 12-inch | 140 | 122 | | 72 | Steam | | | Stock | |
| 735 | do | do | L-3 | | Bored, 7-inch | 145 | 123 | 27? | 46 | Wind | | | do | |
| 736 | A. Stoll | Sec. 30, T. 2 S., R. 13 W. | L-3 | | do | 140 | 122 | 300 | 71 | Gas | | | Irrigation | |
| 737 | do | do | L-3 | | Bored, 10-inch | 140 | 122 | 550 | | do | | | do | |
| 738 | S. R. McCreery | do | L-3 | 1902 | Bored | 135 | 119 | 290 | 38 | do | 850.00 | | Domestic; stock. | |
| 739 | L. Schmidt | do | L-2 | 1896 | Bored, 7-inch | 135 | 117 | 85 | 52 | Wind | 85.00 | $75.00 | do | |
| 740 | Geo. Eysenbeich | Sec. 19, T. 2 S., R. 13 W. | M-2 | 1894 | do | 135 | 115 | 105 | 60 | do | 115.00 | 145.00 | do | |
| 741 | J. Price | Sec. 29, T. 2 S., R. 13 W. | M-2 | 1885 | do | 135 | 115 | 96 | 56 | do | 96.00 | 100.00 | do | |
| 742 | J. F. Davis | do | M-2 | | do | 135 | 118 | 120 | 55 | do | 140.00 | | do | |
| 743 | W. H. Pierce | Sec. 20, T. 2 S., R. 13 W. | M-2 | 1899 | do | 135 | 118 | 163 | 51 | do | 180.00 | 300.00 | do | |
| 744 | August Penkert | Sec. 29, T. 2 S., R. 13 W. | M-3 | 1893 | do | 135 | 122 | 100 | 64 | do | 165.00 | 150.00 | do | |
| 748 | W. F. G. Blaikie | Sec. 28, T. 2 S., R. 13 W. | N-2 | | Bored, 6-inch | 145 | 125 | 96 | 56 | Wind | | | do | |
| 749 | H. O. Wells | do | N-2 | 1902 | Bored, 7-inch | 150 | | 94 | 62 | Hand | 94.00 | 26.00 | Domestic | |
| 750 | J. Mace | do | N-2 | 1878 | do | 150 | 122 | 114 | 65 | Wind | 130.00 | 90.00 | do | |
| 753 | Ray H. Carlton | do | N-3 | 1897 | Bored, 3-inch | 140 | | 86 | 67 | Hand | 45.00 | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 754 | H. L. Gordon | do | N-3 | | Bored, 7-inch | 140 | 78 | 200+ | 72 | Wind | | | Domestic; irrigation. | |
| 756 | do | do | N-3 | | do | 140 | | | 140 | Not raised | | | Not used | |
| 757 | Lillie Tubman | Sec. 29, T. 2 S., R. 13 W. | N-3 | 1903 | Bored, 10-inch | 135 | 120 | 150 | 68 | Gas | 200.00 | 1,000.00 | Irrigation | †50 |
| 758 | do | do | N-3 | | Bored, 7-inch | 135 | 117 | 91 | 57 | Wind | 91.00 | | Domestic | |
| 759 | F. W. Jackson | do | N-3 | 1901 | do | 135 | | | 66 | do | | | Domestic; stock | |
| 760 | P. Quinn | do | N-3 | 1878 | do | 135 | | | 63 | do | | | Domestic | |
| 761 | E. W. Thaxter | Sec. 28, T. 2 S., R. 13 W. | N-3 | 1883 | do | 130 | 118 | 152 | 67 | do | 200.00 | 94.00 | Domestic; stock | |
| 762 | Annette Thaxter | do | N-3 | 1897 | Bored, 10-inch | 130 | 115 | 150 | | Steam | | | Irrigation | |
| 763 | John Saul | Sec. 20, T. 2 S., R. 13 W. | M-2 | 1903 | Bored, 7-inch | 135 | 93 | 97 | 57 | Wind | 97.00 | | do | |
| 765 | S. A. McCrerrey | Sec. 30, T. 2 S., R. 13 W. | L-2 | 1897 | Bored, 9½-inch | 135 | 120 | 235 | | Not raised | 315.00 | | Not used | |
| 766 | Emil Meyer | Sec. 19, T. 2 S., R. 13 W. | M-2 | | Bored, 7-inch | 135 | 121 | 184 | 50 | Wind | | | Domestic; stock | |
| 767 | Burke Bros | do | M-2 | | Bored | 135 | | | 50 | Hand | | | Not used | |
| 768 | Mr. Tucker | do | M-2 | | do | 140 | | | 61 | do | | | Domestic; stock | |
| 769 | J. A. Stephens | do | M-2 | 1890 | Bored, 7-inch | 140 | 128 | 180 | 60 | Wind | | | do | |
| 770 | do | do | M-2 | 1883 | do | 140 | 128 | 160 | 230+ | Gas | | | Irrigation | †50 |
| 771 | Henry Carner | do | M-2 | 1883 | do | 140 | 128 | 160 | 61 | Wind | 175.00 | 175.00 | Domestic; stock | |
| 772 | E. P. Merritt | do | M-2 | 1903 | Bored, 8-inch | 142 | 126 | 98 | 57 | Gas | 100.00 | | do | |
| 773 | W. I. Smart | do | M-2 | 1898 | Bored, 7-inch | 145 | 123 | 84 | 61 | Wind | | | do | |
| 774 | J. M. Schnitker | do | M-2 | 1899 | do | 145 | 130 | 107 | | Gas | | | Irrigation | †45 |
| 775 | Henry G. Hill | do | M-2 | | do | 145 | 130 | 104 | 63 | Wind | | | Domestic; stock | |
| 776 | Peter Wall | do | M-2 | | do | 145 | | | 56 | do | | | Domestic; irrigation. | |
| 777 | Mr. Christman | do | M-2 | | do | 145 | 129 | 90 | 59 | do | | | Domestic; stock | |
| 778 | Joe Walker | do | M-2 | | do | 145 | | | 56 | do | | | do | |
| 779 | L. E. Brockman | do | M-2 | 1903 | do | 145 | 134 | 94 | 60 | do | 94.00 | 50.00 | do | |
| 780 | Mr. Creary | do | M-2 | | do | 145 | 131 | 52 | 69 | do | | | do | |
| 781 | B. Broderson | Los Angeles City | M-1 | 1885 | do | 154 | 132 | 70 | 72 | do | 70.00 | 275.00 | do | |
| 782 | do | do | M-1 | 1903 | Bored, 10-inch | 154 | 132 | 83 | | do | 117.00 | 115.00 | Irrigation | |
| 783 | Jacob Meyer | Sec. 19, T. 2 S., R. 13 W. | L-1 | 1893 | Bored, 7-inch | 153 | 131 | 135 | 50 | do | | 75.00 | Domestic | |
| 784 | B. W. Tully | do | L-1 | 1902 | do | 150 | 130 | 78 | 77 | do | 78.00 | | do | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 785 | Casper Kallenbach | Sec. 19, T. 2 S., R. 13 W. | L-1,2 | 1899 | Bored, 10-inch | 145 | 127 | 82 | | Gas | $113.00 | $1,658.00 | Irrigation | 164 |
| 786 | do | do | L-1,2 | 1903 | Bored, 12-inch | 145 | 127 | 97 | | do | 220.00 | | do | |
| 787 | do | do | L-2 | 1885 | Bored, 7-inch | 145 | 127 | 80 | 68 | Wind | 80.00 | 180.00 | Domestic | |
| 788 | J. M. Weiss | do | L-2 | 1902 | do | 145 | 125 | 80 | 67 | do | 80.00 | 35.00 | Domestic; stock | |
| 789 | V. F. Humbert | do | L-2 | 1892? | do | 145 | 126 | 83 | 70 | do | | 60.00 | do | |
| 790 | Ada Lovell | do | L-2 | 1900 | do | 140 | | 84 | 49 | do | 90.00 | 100.00 | do | |
| 791 | C. W. Burrell | do | L-2 | | do | 140 | | | 60 | do | | | do | |
| 792 | Vito Gwidtta | do | L-2 | | Bored | | | | 55 | do | | | Domestic | |
| 793 | R. W. Brooks | do | L-2 | 1889 | do | 140 | 125 | 73 | 57 | do | | | Domestic; stock | |
| 794 | B. F. Schamp | do | L-2 | 1902 | Bored, 7-inch | 140 | 130 | 120 | 47 | do | 152.00 | | do | |
| 795 | J. M. Wheeler | do | L-2 | 1894 | do | 140 | 126 | 87 | 62 | do | 87.00 | | do | |
| 796 | James Manning | do | L-2 | 1874 | do | 140 | 132 | 88 | 52 | do | | | Domestic | |
| 797 | do | do | L-2 | 1874 | | 140 | | 180 | | | | | | |
| 798 | Mr. Frasier | Sec. 24, T. 2 S., R. 14 W. | L-2 | | Bored, 12-inch | 140 | 125 | 66 | 53 | Wind | | | Domestic; stock | |
| 799 | G. I. Lyttle | Sec. 19, T. 2 S., R. 13 W. | L-2 | 1891 | Bored, 7-inch | 140 | 67 | 130 | 61 | do | 150.00 | 100.00 | Poultry | |
| 800 | Mr. Green | Sec. 24, T. 2 S., R. 14 W. | L-2 | 1896 | Bored | 145 | 130 | 146 | 47 | do | | | Domestic; stock | |
| 801 | S. Park | Sec. 19, T. 2 S., R. 13 W. | L-2 | 1900 | Bored, 7-inch | 140 | | 70 | 49 | do | | | do | |
| 802 | Annie Buser | do | L-2 | 1902 | do | 140 | 125 | 81 | 41 | do | 81.00 | 35.00 | do | |
| 803 | Mrs. M. Blank | do | L-2 | 1897 | do | 140 | | | 64 | do | | | do | |
| 804 | Frank E. Anderson | do | L-2 | 1902 | do | 140 | 125 | 78 | 54 | Hand | 78.00 | | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 806 | Mr. Green | Sec. 24, T. 2 S., R. 14 W. | L-1,2 | | do | 140 | 126 | 77 | 73 | Wind | | | do | |
| 807 | do | do | L-1 | 1902 | Bored, 10-inch | 145 | | 390 | | Gas | 500.00 | 1,500.00 | Irrigation | |
| 808 | R. A. Parmiter | Sec. 19, T. 2 S., R. 13 W. | L-1 | | | 145 | | | 87 | Wind | | | Domestic; stock | |
| 809 | J. Grisenthwaite | do | L-1 | 1898 | Hydraulic, 2-inch. | 145 | 127 | 87 | 82 | do | 30.00 | 36.00 | do | |
| 810 | J. Tasker | do | L-1 | 1895 | Bored, 7-inch | 145 | 127 | 87 | 80 | do | | | do | |
| 811 | Louis Streuber | Sec. 24, T. 2 S., R. 14 W. | L-1 | | do | 140 | 125 | | 47 | do | | | do | |
| 812 | Philip McAnay | do | L-2 | | do | 140 | 130 | 63 | 58 | do | | | Stock | |
| 813 | John Wildasin | Sec. 13, T. 2 S., R. 14 W. | L-1 | 1884 | do | 140 | 130 | 68 | 72 | do | 68.00 | 50.00 | Domestic; stock | |
| 814 | Carl Reaman | do | L-1 | 1875 | do | 143 | 135 | 80 | 74 | do | | | do | |
| 815 | H. M. Boggs | do | L-1 | 1883 | do | 145 | 129 | 70 | 75 | do | | | do | |
| 816 | Qong Ou | do | L-1 | | do | 145 | | | 100 | Hand | | | Domestic | |
| 817 | John Wildasin | do | L-1 | 1886 | do | 145 | 129 | 71 | 63 | Not raised | | | Not used | |
| 818 | do | do | L-1 | 1886 | do | 145 | 129 | 71 | | Hand | | | do | |
| 819 | Mr. Doster | do | L-1 | 1891 | do | 148 | | 50 | 86 | Wind, gas | | 150.00 | Domestic; stock | |
| 820 | Geo. Ninner | do | L-1 | 1891 | do | 148 | 131 | 37 | 82 | Hand | 40.00 | | | |
| 821 | M. J. Golden | Sec. 18, T. 2 S., R. 13 W. | L-1 | 1891 | do | 150 | 130 | 50 | 66 | Wind | | | Domestic | |
| 822 | do | do | L-1 | 1877 | do | 154 | 134 | 315 | | Not raised | | | Not used | |
| 823 | Mr. Rathwell | do | L-1 | 1895 | do | 154 | | | 98 | Wind | | | Domestic; stock | |
| 824 | L. A. Groff | do | L-1 | | do | 155 | 126 | 38 | 74 | do | | | Domestic | |
| 825 | Mr. Rathwell | do | L-1 | 1901 | do | 155 | | 254 | 52 | Gas | | | | |
| 826 | Mrs. Thompson | do | L-1 | | do | 155 | | | 94 | Hand | | | Stock | |
| 827 | Chas. L. Peterson | do | M-1 | 1888 | do | 155 | | 50? | 88 | Wind | | | Domestic; stock | |
| 828 | Mr. Horde | Los Angeles city | M-1 | | do | 155 | | | 83 | do | | | do | |
| 829 | C. Oertly | do | M-1 | 1902 | Bored, 10-inch | 155 | 135 | 60 | 100 | do | 100.00 | 30.00 | do | |
| 830 | Rachael Ware | Sec. 18, T. 2 S., R. 13 W. | M-1 | 1893 | Bored, 7-inch | 157 | 125 | 55 | 82 | Hand | | | Domestic | |
| 831 | H. E. Green | do | M-1 | 1898 | do | 157 | 124 | 51 | 59 | Wind | | | Domestic; stock | |
| 832 | J. R. Toberman | do | L-1 | | do | 154 | | | | do | | | Not used | |
| 833 | A. Stoll | do | M-1 | 1885 | do | 155 | | 63 | 89 | do | 63.00 | 150.00 | Domestic; stock | |
| 834 | Mr. Knowles | do | M-1 | 1895 | do | 155 | 127 | 100 | 61 | do | 100.00 | | do | |
| 835 | E. Mojoneir | do | L-1 | 1902 | do | 155 | 130 | 67 | 96 | do | 67.00 | | Domestic | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 836 | S. Harris | Los Angeles city | M-1 | | Bored, 7-inch | 153 | 126 | 70 | 60 | Wind | | | Domestic; stock | |
| 837 | M. J. Harkness | do | M-1 | | do | 155 | | 40 | 66 | do | | | Domestic | |
| 838 | C. A. Mead | do | M-1 | | do | 155 | 135 | 65 | 64 | do | | $100.00 | Domestic; stock | |
| 839 | Mrs. S. A. Boner | Sec. 19, T. 2 S., R. 13 W. | M-1 | 1895 | do | 155 | 129 | 66 | 67 | do | $66.00 | | do | |
| 840 | N. J. Corette | do | M-1 | | do | 155 | 121 | 69 | 68 | do | | | do | |
| 841 | K. B. Norswing | Los Angeles city | M-1 | 1887 | do | 155 | 130 | 60 | 64 | Wind, gas | | *125.00? | do | |
| 842 | H. Wellensiek | do | M-1 | 1888 | Bored | 155 | | 60 | 62 | Wind | | 30.00 | do | |
| 843 | J. Kroeger | do | M-1 | 1885 | do | 156 | 125 | 58 | 68 | do | | | do | |
| 844 | Main street public school. | do | M-1 | | Bored, 7-inch | 160 | 123 | 55 | 73 | do | | | Domestic | |
| 846 | M. E. Walker | do | M-1 | 1897 | do | 160 | 129 | 59 | 75 | do | 59.00 | 200.00 | Domestic; stock | |
| 847 | Henry Leifer | do | M-1 | | do | 160 | | 40 | 93 | Gas | | | do | |
| 848 | Richard Kidson | do | M-1 | 1874? | do | 165 | 128 | 52 | 84 | Wind | | | do | |
| 849 | L. O. Beamer | do | M-1 | | do | 165 | | 80 | 82 | Wind, gas | 80.00 | | Domestic; irrigation; stock. | |
| 850 | L. E. Sayre | do | M-1 | | do | 160 | 124 | 67 | | Wind | | 65.00 | Domestic; stock | |
| 851 | John Harlan | do | M-1 | 1889 | do | 160 | | 70 | 94 | Wind, gas | | | do | |
| 852 | D. C. Smith | do | M-1 | | do | 170 | 130 | 53 | 75 | Wind | | | do | |
| 853 | Mrs. McCartney | do | M-1 | 1875 | do | 170 | | 125 | 54 | Hand | | | do | |
| 854 | S. J. Linn | do | M-1 | 1889 | do | 170 | | 65 | 69 | Wind | | | Domestic; irrigation. | |
| 855 | Mr. Crum | do | M-1 | | do | 170 | 128 | 66 | 74 | do | | | Domestic; stock | |
| 857 | Geo. W. Evans | Sec. 19, T. 2 S., R. 13 W. | M-2 | 1889 | do | 158 | 128 | 68 | 41 | do | | | do | |
| 858 | do | do | M-1 | | Bored, 14-inch | 158 | 136 | 125 | | Gas | | 1,400.00 | Irrigation | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 859 | S. E. Lawrence | do | M-2 | | Bored, 7-inch | 153 | 138 | 60 | 57 | Wind | | 75.00 | Domestic; stock | | |
| 860 | Carl Brockman | Sec. 20, T. 2 S., R. 13 W. | M-2 | 1886 | do | 155 | 126 | 95 | 51 | do | | | do | | |
| 861 | Otto Shermer | do | M-2 | 1893 | do | 152 | | 93 | 57 | do | 93.00 | 100.00 | do | | |
| 862 | Mr. Lipps | Sec. 19, T. 2 S., R. 13 W. | M-2 | 1893 | Bored, 6-inch | 142 | 124 | 74 | 52 | Hand | | | Domestic | | |
| 863 | W. M. Vontoble | do | M-2 | | Bored, 7-inch | 146 | | | 58 | Wind | | | Domestic; stock | | |
| 864 | J. H. Bargman | Sec. 20, T. 2 S., R. 13 W. | M-2 | | do | 148 | 128 | 93 | 52 | do | 93.00 | 100.00 | do | | |
| 865 | Mrs. Keel | do | M-2 | 1901 | do | 150 | 120 | 113 | 58 | do | 120.00 | 100.00 | do | | |
| 866 | R. Scuffl | Sec. 19, T. 2 S., R. 13 W. | M-2 | | do | 150 | 131 | 62 | 52 | do | | | do | | |
| 867 | C. W. Brockman | Sec. 20, T. 2 S., R. 13 W. | M-2 | 1893 | Bored, 4-inch | 151 | 128 | 70 | 59 | do | | | Domestic | | |
| 868 | do | do | M-2 | 1891 | Bored, 12-inch | 158 | 134 | 113 | 89 | Gas | 200.00 | 1,100.00 | Irrigation | †135 | |
| 869 | do | do | M-1 | 1891 | Bored, 7-inch | 161 | 130 | 62 | 57 | Wind | 62.00 | 35.00 | Domestic; stock | | |
| 870 | Mrs. Julia Brockman | do | M-1 | 1904 | do | 162 | 130 | 68 | 63 | do | | 100.00 | do | | |
| 871 | A. Brockman | do | M-1 | 1889 | do | 163 | 129 | 72 | 69 | Hand | 72.00 | | do | | |
| 872 | do | do | M-1 | 1892 | do | 165 | 130 | 71 | 86 | Wind | 71.00 | 55.00 | Domestic | | |
| 873 | do | do | M-1 | 1897 | Bored, 10-inch | 165 | 130 | 85 | | Gas | 100.00 | 1,300.00 | Irrigation | †90 | |
| 874 | do | do | M-1 | 1897 | do | 165 | 130 | 273 | | do | 450.00 | | do | | |
| 875 | J. J. Lovell | Los Angeles city | N-1 | | Bored, 7-inch | 168 | 128 | 66 | 69 | Wind | | | Domestic | | |
| 876 | D. L. Short | do | N-1 | 1902 | do | 170 | 136 | 74 | 59 | do | 81.00 | 319.00 | do | | |
| 877 | Los Angeles Rwy. Co | do | M-1 | 1904 | Bored, 10-inch | 170 | 130 | 200+ | | Not installed | | | | | |
| 878 | Mrs. Maggie Sharp | do | N-1 | 1883 | Bored, 7-inch | 170 | 130 | 61 | 67 | Wind | | | Domestic | | |
| 879 | J. P. Thremer | do | N-1 | 1888 | do | 170 | 128 | 70 | 61 | do | | | do | | |
| 880 | South Park | do | N-1 | 1901 | Bored, 10-inch | 171 | 129 | 172 | 59 | Gas | | 95.00 | Irrigation | | |
| 881 | A. F. Smith | do | N-1 | | Bored, 7-inch | 170 | 127 | 59 | 58 | Wind | | | Domestic; stock | | |
| 882 | L. M. Messner | do | N-1 | | do | 170 | | 64 | | do | | 75.00 | do | | |
| 883 | A. Snyder | do | N-1 | | do | 170 | | | 60 | do | | | Domestic | | |
| 884 | John Henderson | do | N-1 | | do | 175 | | 90 | 69 | do | | | Domestic; stock | | |
| 885 | Henry Sherer | Sec. 20, T. 2 S., R. 13 W. | N-2 | 1885? | do | 149 | 133 | 82 | 46 | do | | 225.00 | do | | |
| 886 | Mr. Thompson | do | N-2 | | do | 151 | | | | Gas | | | Irrigation | | |
| 887 | J. A. Althouse | do | N-2 | 1904 | do | 152 | | | 76 | Wind | | | Domestic | | |
| 888 | J. T. Morgan | do | N-2 | | do | 152 | 118 | 90 | 72 | Gas | | | Domestic; stock | | |
| 889 | Geo. W. Throop | do | N-2 | 1903 | do | 155 | 123 | 77 | 75 | Wind | 83.00 | 85.00 | do | | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 890 | Los Angeles Real Estate Co. | Sec. 20, T. 2 S., R. 13 W | N-2 | 1896 | Bored, 7-inch | 155 | 123 | 77 | | Not raised | $80.00 | | Not used | |
| 891 | L. H. Belter | do | N-2 | 1883 | do | 155 | 122 | 78 | | Wind | | | Domestic | |
| 892 | Mrs. Killenger | do | N-2 | | do | 155 | | 70 | 68 | Gas | | | Domestic; stock | |
| 893 | Ascott Park Jockey Club. | do | N-1 | 1903 | Bored, 14-inch | 170 | 128 | 270 | 63 | Electric motor | | | Race track | 120 |
| 894 | W. A. Bly | Los Angeles city | N-1 | 1901 | Bored, 7-inch | 177 | 133 | 72 | 59 | Wind | | $250.00 | Domestic | |
| 895 | Henry Hekri | do | N-1 | 1897 | do | 177 | 122 | 70 | 67 | do | 70.00 | 145.00 | do | |
| 896 | Mrs. J. E. Thompson, sr. | do | N-1 | 1899? | do | 170 | 140 | 74 | 59 | Electric motor | | | Domestic; irrigation. | |
| 897 | D. E. Miller | do | N-1 | 1900 | do | 170 | | 70 | 55 | Wind | | | Domestic | |
| 900 | H. N. Petrie | do | N-1 | 1900 | do | 170 | | 70 | 43 | do | 50.00 | 150.00 | do | |
| 901 | Mr. Sutherland | do | N-1 | | do | 170 | | | 56 | do | | | do | |
| 902 | Peter Black | do | N-1 | 1900 | do | 170 | | 75 | 58 | do | | | Domestic; stock | |
| 903 | L. F. Brashear | do | N-1 | | do | 170 | | | 59 | do | | | Domestic | |
| 904 | Mrs. Maschaff | do | N-1 | | do | 170 | | | 61 | do | | | do | |
| 905 | Michael DePiaro | do | N-1 | 1898 | Bored | 170 | 121 | 74 | 65 | do | *225.00 | | do | |
| 906 | California Sewer Pipe Co. | do | N-1 | 1895 | Bored, 12-inch | 170 | 104 | 73 | 67 | Steam | | | Manufacturing | 1½ |
| 907 | F. K. Parker | do | N-1 | | Bored, 7-inch | 175 | | | 65 | Wind | | | Domestic | |
| 908 | E. B. Price | do | N-1 | 1897 | do | 174 | 121 | 73 | 58 | do | | | do | |
| 909 | Mr. Thornton | do | N-1 | | do | 174 | | 60 | 55 | do | | | do | |
| 910 | Mrs. Lizzie Preddy | do | N-1 | 1900 | do | 174 | | 70 | 61 | do | | 65.00 | do | |
| 911 | J. E. Gayman | do | N-1 | 1894? | do | 174 | 126 | 69 | 82 | do | | | do | |
| 912 | M. J. Russell | do | N-1 | 1899 | do | 174 | 130 | 66 | 58 | do | *200.00 | | do | |
| 913 | Anna Mansfield | do | N-1 | 1899 | do | 170 | 130 | 75 | 59 | do | *300.00 | | do | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 914 | Mrs. Carnigie | do | N-1 | 1901 | do | 170 | | | 65 | do | | | do | | |
| 915 | Wm. Power | do | N 1 | 1901 | do | 170 | | | 66 | | *250.00 | | do | | |
| 916 | Mrs. W. H. McKie | do | N 1 | 1902 | do | 170 | 129 | 75 | 65 | Wind | 74.00 | 67.00 | do | | |
| 917 | Ed. Ross | do | N-1 | | do | 170 | | | 64 | do | | | do | | |
| 918 | W. H. Price | do | N-1 | 1902 | do | 172 | 124 | 73 | 55 | do | 73.00 | +130.00 | do | | |
| 919 | E. A. Burlingame | do | N-1 | 1901 | do | 178 | | 67 | | do | 75.00 | 36.00 | do | | |
| 920 | Thos. Elliott | do | N-1 | 1901 | do | 178 | 138 | 69 | | do | 70.00 | 36.00 | do | | |
| 921 | J. T, Trowbridge | do | N-1 | 1901 | do | 174 | | | 57 | do | *210.00 | | do | | |
| 922 | J. P. Lee | do | N-1 | | do | 175 | 125 | 72 | 60 | do | | | Stock | | |
| 923 | do | do | N-1 | | do | 175 | 112 | 77 | 60 | do | | | Domestic | | |
| 925 | L. M. Appelby | do | N-1 | 1899 | do | 175 | | 72 | 66 | do | 75.00 | | Domestic; stock | | |
| 926 | F. J. Grandy | do | N-1 | 1897 | do | 175 | 119 | 71 | | | | | | | |
| 927 | M. F. O'Dea | Los Angeles city | N-1 | | Bored | 175 | | | | Wind, gas | | | Not used | | |
| 929 | H. V. Stockely | do | N-1 | | Bored, 7-inch | 172 | | | 63 | Wind | | | Domestic | | |
| 930 | Mr. White | do | N-1 | | do | 175 | | | 59 | do | | | do | | |
| 931 | M. I. Wheeler | do | N-1 | | do | 175 | 116 | 65 | 59 | do | | | do | | |
| 932 | Mr. Barnhart | do | N-1 | | do | 175 | | | 56 | do | | | do | | |
| 933 | Ed Kahl | do | N-1 | 1899 | do | 175 | 131 | 69 | 58 | do | | | do | | |
| 934 | C. M. Lincoln | do | N-1 | 1879? | do | 175 | 125 | 87 | 59 | do | | | do | | |
| 935 | E. F. & W. H. Duvall | do | N 1 | 1899 | do | 175 | | | 44 | do | | | Domestic; stock | | |
| 936 | Mrs. McKinley | do | N-1 | 1875 | do | 174 | 129 | 80 | | do | | | Not used | | |
| 937 | H. E. Huntington | do | N 1 | 1900 | Bored, 9½-inch | 176 | | 309 | | Electric motor | | | Irrigation | †85 | |
| 938 | J. A. Miller | do | N-1 | | Bored, 7-inch | 178 | 123 | 63 | 55 | Wind | | | Domestic | | |
| 939 | do | do | N-1 | 1900? | Bored | 178 | | 72 | 55 | do | | | do | | |
| 940 | A. C. Decker | do | N-1 | 1903 | Bored, 7-inch | 176 | 123 | 62 | 54 | do | 54.45 | 30.00 | do | | |
| 941 | S. V. Gates | do | N-1 | 1899 | Bored | 175 | | | 59 | do | | | do | | |
| 942 | H. K. Bennett | do | N-1 | 1902 | Bored, 7-inch | 176 | 124 | 72 | 63 | do | 56.00 | +141.00 | do | | |
| 943 | M. E. Shooley | do | N-1 | 1900 | do | 176 | 124 | 72 | 55 | do | 107.20 | +218.00 | do | | |
| 944 | Mrs. Irene Wright | do | N-1 | 1887? | do | 176 | 129 | 52 | | do | | | Not used | | |
| 945 | C. H. Ghreist | do | N-1 | 1900 | do | 178 | | 72 | 62 | do | | | Domestic | | |
| 946 | L. J. Bliss | do | N-1 | | | 178 | | 60 | 60 | do | | | do | | |
| 947 | John Herman | do | N-1 | 1897 | Bored | 178 | 123 | 66 | 54 | Electric motor | | 400.00 | do | | |
| 948 | John F. Monroe | do | N-1 | 1896 | Bored, 6-inch | 178 | 121 | 60 | 59 | Wind | | | do | | |
| 949 | W. F. Dunham | do | N-1 | 1901 | Bored, 7-inch | 178 | | 60 | 57 | do | | | do | | |
| 950 | D. A. Kirkpatrick | do | N-1 | 1901 | do | 176 | 126 | 64 | 59 | do | | 20.00 | do | | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 951 | Mrs. Bennett | Los Angeles city | N-1 | 1895? | Bored, 7-inch | 178 | 123 | 62 | 55 | Wind | | | Domestic; stock | |
| 952 | Earnest Eberhardt | do | N-1 | 1902 | do | 178 | 119 | 76 | 57 | do | | | Domestic | |
| 953 | Mrs. Heuber | do | N-1 | | do | 178 | 125 | 58 | 60 | do | | | do | |
| 954 | D. M. Baldwin | do | N-1 | 1891 | do | 178 | 122 | 64 | 57 | do | | | do | |
| 955 | G. Dumont | do | N-1 | 1900 | do | 178 | 123 | 70 | 60 | do | | | do | |
| 956 | P. Purcell | do | N-1 | 1899 | do | 178 | | | 61 | do | | $300.00 | do | |
| 957 | A. L. & D. F. Wilson | do | N-1 | 1887 | do | 177 | | | 55 | do | *$350.00 | | do | |
| 958 | W. F. Sherwood | do | N-1 | | do | 178 | | | 57 | do | | | do | |
| 959 | Mr. Webb | do | N-1 | | do | 178 | | | 60 | do | | | do | |
| 960 | D. M. Brewer | do | N-1 | 1903 | do | 178 | 132 | 75 | 58 | do | *300.00 | | do | |
| 961 | Mr. Owens | do | N-1 | | Bored, 4-inch | 178 | | | 56 | do | | | Stock | |
| 962 | Miss Russell | do | N-1 | 1903 | Bored | 178 | | | 60 | do | | | Domestic; stock | |
| 963 | J. C. M. N. Garner | do | N-1 | 1902 | do | 178 | | 70+ | 55 | do | 70.00 | 100.00 | Domestic | |
| 964 | L. W. James | do | N-1 | 1901 | Bored, 7-inch | 178 | | 72 | 65 | Wind, hand | 54.25 | 98.00 | do | |
| 967 | H. R. Smith | do | N-1 | 1898 | do | 178 | 126 | 72 | 60 | Wind | 80.00 | 100.00 | do | |
| 968 | John Engle | do | N-1 | | do | 176 | | 70+ | 50 | do | | | Domestic; stock | |
| 969 | Equitable Trust and Improvement Co. | do | N-1 | | Bored | 176 | | | 65 | do | | | Domestic | |
| 970 | C. Sanders | do | N-1 | | do | 178 | | | 60 | do | | | do | |
| 971 | Mr Ingersoll | do | N-1 | | do | 178 | | | 60 | do | | | do | |
| 972 | M. C. Daugherty | do | N-1 | | Bored, 7-inch | 178 | | | 60 | do | | | do | |
| 973 | John Cornelson | do | N-1 | 1899 | do | 178 | | | 59 | do | | | do | |
| 974 | Santa Fe R. R | do | N 1 | 1894 | do | 170 | 128 | 70 | 61 | do | | | Stock | |
| 975 | W. W. Alived | Sec. 21, T. 2 S., R. 13 W. | N 2 | 1883 | do | 160 | 135 | 55 | 79 | do | | | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 976 | Mr. Slauson | do | N-2 | | Bored, 10-inch | 155 | 125 | 148 | | do | | | | |
| 977 | I. Madill | do | N-1 | 1895? | Bored, 7-inch | 155 | | | 80 | do | | | Domestic; stock | |
| 978 | R. J. Lang | do | N-2 | 1893 | do | 155 | 127 | 88 | 55 | do | 100.00 | 185.00 | do | |
| 979 | Mr. Slauson | Sec. 20, T. 2 S., R. 13 W. | N-2 | | do | 160 | | | 73 | do | | | Irrigation | |
| 980 | W. Wieland | Sec. 21, T. 2 S., R. 13 W. | N-2 | 1884 | do | 160 | | | 89 | Gas | | 150.00 | Domestic | |
| 981 | Mr. Slauson | Sec. 20, T. 2 S., R. 13 W. | N-2 | 1900 | Bored, 12-inch | 160 | 125 | 300 | | do | | | Irrigation | †235 |
| 982 | do | do | N-2 | 1900 | do | 160 | 125 | 270 | | do | | | do | |
| 983 | W. Niece | Sec. 29, T. 2 S., R. 13 W. | N-3 | | Bored, 7-inch | 134 | 120 | 52 | 60 | Wind | | | Domestic; stock | |
| 984 | T. H. Kennan | do | N-3 | 1898 | Bored, 2-inch | 137 | 122 | 105 | 68 | do | 50.00 | 100.00 | do | |
| 985 | do | do | N-3 | 1899 | Bored, 9½-inch | 135 | 124 | 42 | 167 | Not raised | 201.00 | | Not used | |
| 986 | Louis Streuber | Sec. 24, T. 2 S., R. 14 W. | L-1 | 1887 | Bored, 7-inch | 140 | 126 | 440 | | Gas | | 810.00 | Irrigation | |
| 987 | do | do | L-1 | 1899 | Bored, 12-inch | 140 | 122 | 80 | 103 | do | | | do | |
| 988 | A. Ducuzan | San Pedro | L-9 | 1904 | Bored, 6-inch | 30 | 16 | 27 | 93 | Hand | | | Domestic; stock | |
| 989 | Sing | do | L-9 | | do | 28 | | 160 | 66 | Wind | | | Domestic | |
| 990 | J. Gless | do | L-9 | | Bored, 7-inch | 36 | 21 | | 38 | Gas | | | Irrigation | |
| 991 | S. Haigh | do | L-9 | 1898 | do | 30 | | 220 | 40 | Steam | | | Domestic; irrigation. | |
| 992 | D. H. Thrasher | do | L-9 | | Bored | 30 | | | 38 | Wind | | | Domestic | |
| 993 | Pete Lalich | do | L-9 | 1901 | Bored, 7-inch | 27 | 7 | 100+ | 39 | do | | | do | |
| 994 | Thos. Oliver | do | K-9 | 1898 | do | 40 | 15 | 183 | 32 | Gas | *1,500.00 | | Domestic; irrigation. | †35 |
| 995 | N. S. Southmayd | do | L-9 | 1902 | Bored 10-inch | 40 | 21 | 200 | 38 | do | 397.00 | 500.00 | Domestic; stock | |
| 996 | J. G. Smith | do | L-9 | 1896 | Dug, 5 by 5 foot | 50 | 28 | 29 | | Gas, wind | | | Domestic; irrigation. | |
| 997 | do | do | L-10 | 1899 | Bored, 7-inch | 50 | 28 | 162 | 30 | do | | ‡80.00 | Irrigation | |
| 998 | do | do | L-10 | 1902 | Bored, 10-inch | 50 | | 200 | 30 | do | 286.00 | | do | |
| 999 | F. C. Carrell | do | L-10 | 1900? | Bored, 6-inch | 50 | | 262 | 34 | Wind | | | Domestic | |
| 1000 | O. L. Gridley | do | L-10 | | Bored, 4-inch | 55 | 25 | | 31 | do | | | do | |
| 1001 | F. H. Carrell | do | L-10 | 1900? | Bored | 55 | 29 | 400 | | Not raised | | | Not used | |
| 1002 | McKinley Home | do | L-10 | | do | 55 | | | 34 | Gas | | | Domestic | |
| 1003 | J. H. Bathrick | do | L-10 | 1904 | Bored, 4-inch | 60 | 30 | 133 | 29 | Wind | 109.00 | 163.00? | do | |
| 1004 | R. E. Ford | do | L-10 | 1897 | do | 55 | 33 | 288 | 29 | do | 210.00 | 37.00 | Domestic; stock | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1005 | J. W. Barnett | San Pedro | L-10 | 1903 | | 55 | 29 | 350 | 27 | Hand | | | Domestic; stock | |
| 1006 | Geo. Crookshank | do | L-10 | 1903 | Bored, 10-inch | 50 | 25 | 250 | 34 | Wind | $400.00 | $100.00 | Domestic; irrigation. | |
| 1007 | Mrs. John Francis | do | L-10 | 1897 | Bored, 7-inch | | | | 34 | do | | | Domestic; stock | |
| 1008 | Fred Pierce | do | L-11 | | Bored | 35 | | | 27 | do | | | do | |
| 1009 | C. E. Guyre | do | L-12 | | Bored, 7-inch | 55 | | | 28 | do | | | do | |
| 1010 | J. M. Carson | do | L-12 | 1903 | Bored | 55 | | | 26 | Wind, gas | | | do | |
| 1011 | Geo. T. Stewart | do | L-13 | 1899 | Dug, 3½ by 3½ foot. | 78 | 51 | 28 | 230+ | Wind | | | do | |
| 1012 | Scrivens Bros | do | L-13 | 1900 | Dug, 3 by 4 foot | 70 | 69 | 21 | 75 | Hand | | | do | |
| 1013 | A. M. Scriven | do | L-13 | 1900 | Bored, 8-inch | 70 | 50 | 253 | 29 | Wind, steam | 400.00 | 2,000.00 | Domestic; irrigation. | †70 |
| 1014 | do | do | L-13 | 1900 | do | 70 | | | 85 | Wind | 27.00 | 50.00 | Domestic | |
| 1015 | James Crowley | do | M-13 | 1896 | Driven, 2½-inch | 70 | 50 | 36 | 101 | do | | | Domestic; stock | |
| 1016 | J. M. Carson | do | M-13 | | Bored, 7-inch | 48 | | | 36 | do | | | do | |
| 1018 | A. Vetter | do | K-12 | | do | 90 | 85 | 150+ | 103 | do | | | do | |
| 1020 | Wm. Murdock | do | M-13 | 1894 | Dug, 40 feet; bored, 10 feet. | 65 | 20 | 50 | 101 | do | | | do | |
| 1021 | R. L. Watson | do | N-13 | 1894 | Bored, 2-inch | 35 | 30 | 40 | 40 | Hand | 40.00 | | do | |
| 1022 | do | do | N-13 | 1897 | Dug | 40 | 18 | 25 | 121 | Wind | | | do | |
| 1023 | Wm. Kupferle | do | N-14 | 1877 | Bored, 12-inch | 70 | 38 | 60 | 82 | do | 125.00 | 135.00 | do | |
| 1024 | P. C. Traub | do | N-14 | 1892 | Bored, 7-inch | 55 | | 90 | 26 | do | | | do | |
| 1025 | James Brayton | do | N-14 | 1884 | do | 55 | 29 | 90 | 64 | do | | | do | |
| 1026 | H. F. Lembke | do | N-14 | | Bored, 12-inch | 65 | | 50 | 167 | do | | | do | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1027 | John Hohlbauch | do | N-14 | 1885 | Dug, 45 feet; bored, 7-inch, 115 feet. | 65 | 30 | 160 | 53 | do | | | do | |
| 1030 | John Kase | do | M-14 | 1891 | Bored, 7-inch | 55 | 30 | 78 | 50 | do | | | do | |
| 1031 | German Methodist Church. | do | M-14 | 1899 | Bored | 55 | | 90 | 53 | do | | | Domestic | |
| 1032 | Mrs. A. O. Springer | do | M-14 | 1884 | Dug, 3½ by 3½ foot. | 53 | 30 | 25 | 117 | do | | | Domestic; stock | |
| 1033 | H. A. Clark | do | M-14 | 1898 | Bored, 7-inch | 54 | 30 | 200 | 73 | do | | | do | |
| 1034 | G. A. Neuffer | do | M-14 | 1888 | Dug, 3½ by 3½ foot. | 55 | 25 | 32 | 72 | do | | | Domestic | |
| 1035 | S. S. Lampson | do | M-14 | 1899? | Dug, 3 by 3 foot | 55 | 30 | 28 | 167 | do | | 125.00 | do | |
| 1036 | Lincoln school district | do | M-14 | | Bored | 55 | | | | do | | | do | |
| 1037 | F. M. Whelchel | do | M-14 | | Bored, 7-inch | 55 | | | 33 | do | | | Domestic; stock | |
| 1039 | Mrs. L. M. Phillips | do | M-15 | 1876 | Dug, 26 feet; bored, 14 feet. | 49 | 29 | 40 | 70 | do | | | do | |
| 1040 | Luckerman estate | do | M-15 | 1884 | Dug, 5-foot diameter. | 48 | 25 | 25 | 59 | do | | 100.00 | do | |
| 1041 | Henry Kolkhorst | do | M-16 | 1901 | Bored | 30 | | 345 | 108 | do | | | Domestic | |
| 1042 | B. McCoy | do | M-16 | 1897 | Dug, 4 by 4 foot; bored, 11-inch diameter. | 30 | 10 | 30 | 88 | do | 40.00 | 90.00 | Domestic; stock | |
| 1047 | Mrs. Scomos | do | N-16 | | | 13 | | | 34 | Hand | | | | |
| 1048 | F. Hancock | do | N-16 | 1880 | Bored, 2-inch | 13 | | | 31 | do | | | Domestic | |
| 1049 | Chas. Menveg | do | N-16 | | | 9 | | | 230+ | do | | | do | |
| 1050 | Geo. O'Brien | do | N-16 | 1881 | Dug; bored, 1¼-inch. | 9 | 7 | 12 | 38 | do | | | do | |
| 1051 | do | do | N-16 | 1902 | Dug, 6-foot diameter, 8 feet; bored, 1¼-inch, 15 feet. | 9 | 7 | 23 | 89 | Not raised | | | Not used | |
| 1052 | Seaside Water Co | do | N-16 | 1882 | Dug, 20 by 40 foot. | 10 | 7 | 22 | 114 | Steam | | | Domestic | |
| 1053 | do | do | N-16 | 1900 | Bored, 10-inch | 10 | 7 | 500 | | Not raised | | | Not used | |
| 1054 | J. B. Nichols | do | N-16 | | Bored | 8 | 5 | 12 | 43 | Hand | | | Domestic | |
| 1055 | John Mattos | do | N-16 | 1903 | Bored, 1½-inch | 9 | 5 | 20 | 29 | do | 15.00 | | do | |
| 1058 | John Joseph | do | N-16 | 1900 | Dug, 6 by 6 foot | 26 | 23 | 20 | 79 | do | | | Domestic; stock | |
| 1059 | Wilmington Cemetery | do | N-15 | | Bored | 55 | | | 29 | Wind | | | Irrigation | |
| 1060 | Banning Bros | do | N-15 | 1892? | Dug, 20-foot diameter. | 60 | 27 | 42 | 51 | Gas | | | Domestic; irrigation; stock. | |

*Wells in Redondo quadrangle*—Continued.

| Number of well. | Owner. | Location. | Map location. | Year completed. | Class of well. | Elevation of surface (feet). | Elevation of water (feet). | Depth of well (feet). | Solids per 100,000. | Method of lift. | Cost of well. | Cost of machinery. | Use of water. | Quantity of water (miner's inches). |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1061 | Wm. Mauger | San Pedro | N-15 | | Bored, 14-inch | 60 | 32 | 42 | 46 | Wind | | | Domestic; stock | |
| 1064 | John Gellus | do | N-15 | 1894 | Bored, 7-inch | 40 | | 97 | 31 | do | *$200.00 | | Domestic | |
| 1065 | J. H. Putney | do | N-15 | 1888? | do | 40 | 22 | 115 | 32 | do | | | Domestic; stock | |
| 1066 | do | do | N-15 | 1902 | Dug, 5 by 8 foot. | 40 | 22 | 21 | 69 | Steam | 35.00 | | Irrigation | |
| 1067 | Nelson Storey | do | N-15 | 1884 | Bored, 6-inch | 40 | 24 | 60 | 36 | Wind | | | Domestic; stock | |
| 1068 | Seaside Water Co | do | N-15 | 1903 | Bored, 12-inch | 35 | 23 | 783 | 51 | Steam | | | Domestic | †77 |
| 1069 | do | do | N-15 | 1902 | do | 35 | | 380 | | do | | | do | |
| 1072 | Mrs. E. E. Hayes | do | N-15 | 1874 | Bored, 4-inch | 35 | | | 29 | Wind | | | do | |
| 1073 | do | do | N-15 | 1872 | Bored, 7-inch | 35 | 16 | 33 | 73 | do | | | Domestic; stock | |
| 1074 | Wm. Uldt | do | N-15 | 1874 | Bored, 12-inch | 25 | 13 | 24 | 101 | do | | +$300.00 | Domestic | |
| 1076 | Mrs. J. Luede | do | N-16 | 1874 | | 20 | | | 63 | Hand | | 37.00 | do | |
| 1077 | John Francis | do | N-16 | | Bored, 7-inch | 20 | 10 | 86 | 36 | Wind | | | do | |
| 1078 | T. M. Matthews | do | N-16 | 1901 | Dug, 6 by 6 foot. | 21 | 10 | 19 | 65 | Wind, hand | | | do | |
| 1079 | Alehanda Robbins | do | N-16 | | do | 24 | 10 | 15 | 94 | do | | | Domestic; stock | |
| 1080 | A. G. Smith | do | N-16 | 1903 | Dug, 4 by 4 foot. | 23 | 10 | 18 | 85 | do | 58.00 | 50.00 | Domestic | |
| 1081 | H. Hilderbrandt | do | N-16 | 1878 | Dug, 5 by 8 foot. | 18 | 5 | 17 | 61 | do | 58.00 | 50.00 | do | |
| 1082 | Frank Moniz | do | N-16 | 1903 | Dug, 3-foot diameter. | 16 | | 12 | 88 | Hand | | | do | |
| 1083 | Edward Croak | do | N-16 | 1903 | Dug, 4-foot diameter. | 11 | 5 | 9 | 47 | do | 15.00 | | do | |
| 1084 | Lorenzo Hegera | do | N-16 | | Bored, 2-inch | 10 | | | 60 | do | | | do | |
| 1085 | Mrs. Mahar | do | N-16 | 1867 | do | 10 | | | 56 | do | | | do | |
| 1086 | H. D. Parsons | do | M-16 | 1874 | Dug, 6 by 6 foot. | 25 | 4 | 22 | 79 | Wind | | | Domestic; stock | |
| 1087 | T. D. Holladay | do | M-16 | 1874 | Dug, 4 by 4 foot. | 25 | 5 | 21 | 90 | do | | | do | |
| 1088 | J. M. Medena | do | M-16 | 1903 | Dug, 4 by 5 foot. | 26 | 6 | 24 | 55 | do | *250.00 | | Domestic | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1089 | Mr. Seaman | do | M-15, 16 | 1890? | Bored, 7-inch | 40 | 21 | 100 | 33 | do | | | Domestic; stock | |
| 1090 | Bathman & Bradshaw | do | M-16 | 1874 | Bored, 12-inch | 21 | 0 | 40 | 37 | do | | | do | |
| 1091 | J. P. Silva | do | M-16 | | Bored, 7-inch | 21 | | | 34 | do | | | Domestic | |
| 1092 | P. C. Peterson | do | N 16 | 1903 | Dug, 4 by 5 foot. | 20 | 2 | 20 | 82 | do | 45.00 | 185.00 | do | |
| 1093 | H. A. Matthewson | do | M-16 | 1901? | Bored, 12-inch | 20 | 2 | 30 | 47 | do | | | Domestic; stock | |
| 1094 | Miss S. E. Winslow | do | M-16 | | Dug, 5-foot diameter. | 20 | 3 | 20 | 100 | do | | | Domestic | |
| 1095 | Manuel Gomez | do | M-16 | 1880 | Bored | 20 | | 25+ | 60 | do | | | do | |
| 1096 | Wilmington public school. | do | N-16 | | Bored, 7-inch | 25 | | | 44 | do | | | do | |
| 1097 | David Moore | do | M-15 | 1890 | do | 60 | 30 | 116 | 36 | do | | | Domestic; stock | |

# INDEX.


Page.

Artesian areas, diminution of ..... 17-18
in Redondo and Santa Monica quadrangles, location of, maps showing ..... Pocket.
in region, location of..... 14-15
maps showing ..... Pocket.
Artesian Water Co., system of..... 13
Ballona artesian basin, location of..... 15
permanence of ..... 18
Ballona Creek, irrigation from..... 13
mouth of, view near..... 10
valley of, character of..... 11
Brainard L. B., work of..... 21
Canals in Redondo and Santa Monica quadrangles, location of, maps showing ..... Pocket
Ciénega, wells near..... 13, 14
Climate, character of..... 10
Coastal plain, bluffs of, view of ..... 12, 14
character and extent of ..... 10-11
map of..... Pocket.
quadrangles in ..... 9
Colegrove, artesian basin near ..... 15, 18
Contours, hydrographic, map showing.. Pocket.
position of..... 15
Crops, character of ..... 12
Electrolytic bridge, use of..... 20
Fisk, A. J., work of..... 21
Gardena, dry lake near..... 11
Hamlin, Homer, acknowledgments to ..... 21
Lands, irrigated, in Redondo and Santa Monica quadrangles, location of, maps showing..... Pocket.
Los Angeles, rainfall at ..... 16-17
Los Angeles River, water supply from ..... 13, 14
McCarton, A. P., work of..... 21
Maps, description of..... 18-21
of Redondo and Santa Monica quadrangles ..... Pocket.

Page.

Palms, wells near ..... 15
Pumping plants, location of, in Redondo and Santa Monica quadrangles, maps showing ..... Pocket.
use of..... 14
Quadrangle, definition of ..... 9
Rainfall at Los Angeles ..... 16
Redondo quadrangle, artesian area in, diminution of ..... 17-18
irrigated lands in ..... 17, 19
maps of..... Pocket.
pumping in ..... 15
wells in..... 17
Santa Monica, bench lands near, view of .. 12
Santa Monica quadrangle, artesian area in, diminution of ..... 17-18
irrigated lands in..... 17-19
maps of..... Pocket.
pumping in..... 15
wells in..... 17
Sewage, irrigation by..... 19
Soil, character of ..... 11-12
Water, source of ..... 12-13
Water, underground, alkali in ..... 16
development of..... 9
distribution of..... 14-16
levels of, in Redondo and Santa Monica quadrangles, map showing.. Pocket.
permanence of ..... 16-18
solids in, determination of ..... 20-21
distribution of, map showing. 20
source of..... 14
Wells in Redondo quadrangle, data concerning..... 17, 61-103
in Redondo quadrangle, map showing ..... Pocket.
in region, number of ..... 17-18
in Santa Monica quadrangle, data concerning..... 17, 22-61
map showing..... Pocket.
White, W. N., work of..... 21




O

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

# FIELD MEASUREMENTS

OF

# THE RATE OF MOVEMENT OF UNDERGROUND WATERS

BY

CHARLES S. SLICHTER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

# CONTENTS.


| | Page |
|---|---|
| Letter of transmittal | 7 |
| Introduction | 9 |
| Chapter I. The capacity of a sand to transmit water | 10 |
| Factors influencing flow | 10 |
| Transmission constant | 10 |
| Chapter II. Underflow meter used in measuring velocity and direction of movement of underground water | 16 |
| Types of apparatus | 16 |
| Test wells | 16 |
| Direct-reading instruments | 19 |
| Recording instruments | 25 |
| Chapter III. Laboratory experiments on the flow of water through sands and gravels | 29 |
| Objects of the experiments | 29 |
| Experiments in the horizontal tank | 29 |
| Experiments in the vertical tank | 41 |
| Accuracy of the electric method of determining the velocity of ground waters | 49 |
| Chapter IV. Measurements of the underflow at the narrows of Rio Hondo and San Gabriel River, California | 50 |
| Chapter V. Measurements of the underflow at the narrows of Mohave River near Victorville, Cal | 55 |
| Conditions at the station | 55 |
| Description of experiments | 57 |
| Quality of water | 63 |
| Chapter VI. Measurements of the rate of the underflow on Long Island, New York | 65 |
| Conditions existing at the stations | 65 |
| Influence of the rainfall upon the rate of motion of ground waters | 69 |
| Seepage waters from ponds and reservoirs | 72 |
| Influence of pumping upon the rate of motion of ground waters near some of the Brooklyn driven-well stations | 81 |
| Conclusion | 85 |
| Chapter VII. Specific capacity of wells | 86 |
| General principles | 86 |
| Tests | 91 |
| Test I | 91 |
| Seepage and evaporation | 92 |
| Test II | 92 |

Page.

Chapter VIII. The California "stovepipe" method of well construction for water supply ..... 98
Mode of construction ..... 98
Advantages of stovepipe construction ..... 101
Cost of construction ..... 101
Well rigs ..... 102
Yield of wells ..... 103
Chapter IX. Tests of typical pumping plants ..... 104
Test of pumping plant of Felix Martinez, near El Paso, Tex ..... 104
Pumping plants of J. A. Smith, near El Paso, Tex ..... 106
Test of Roualt's pumping plant, near Las Cruces, N. Mex ..... 109
Test of Horaco Ranch Company's well No. 1, Berino, N. Mex ..... 111
Summary of results of tests at pumping plants in valley of the Rio Grande, New Mexico and Texas ..... 112
Determination of vacuum ..... 113
Specific capacity ..... 113
Cost and operating expenses ..... 114
Fuel cost ..... 114
Comments on the Rio Grande pumping plants ..... 117
Index ..... 121

# ILLUSTRATIONS.


| | | Page. |
|---|---|---|
| PLATE I. | First underflow stations near Garden, Kans.: *A*, Station 1, near "Point of Rock;" *B*, Station 2, south of island | 10 |
| II. | Scale for graphic estimation of transmission constant of a sand | 14 |
| III. | *A*, Ram for driving wells; *B*, Pulling casing with railroad jacks | 18 |
| IV. | Electrode and perforated brass buckets used in charging wells | 18 |
| V. | *A*, Underflow meter; *B*, Commutator-clock | 20 |
| VI. | *A*, Small well jetting rig; *B*, Recording instruments in field box | 26 |
| VII. | Charts made by recording ammeter | 26 |
| VIII. | Vertical tank used in laboratory experiments | 42 |
| IX. | Narrows of Mohave River, California | 56 |
| X. | Driving well at underflow station at narrows of Mohave River | 58 |
| XI. | Driving test wells in the gorge of Mohave River | 58 |
| XII. | *A*, 12-inch "stovepipe" starter; *B*, Two lengths of stovepipe casing | 98 |
| XIII. | *A*, Side view of California well rig; *B*, Front view | 100 |
| XIV. | *A*, Casing perforator; *B*, Rear view of well rig | 102 |
| XV. | California well rig and artesian well flowing 5,250,000 gallons per twenty-four hours | 102 |
| FIG. 1. | Pipe joint made with hydraulic coupling | 17 |
| 2. | Plan of arrangement of test wells | 18 |
| 3. | Diagram illustrating manner of working of electric underflow meter | 20 |
| 4. | Ampere curves at station 5, San Gabriel River, California | 22 |
| 5. | Ampere curves at station 1, Long Island, New York | 24 |
| 6. | Ampere curves at station 10, Garden, Kans | 27 |
| 7. | Plan of horizontal tank | 31 |
| 8. | Experiment 4, horizontal tank | 33 |
| 9. | Experiment 6, horizontal tank | 33 |
| 10. | Experiment 8, horizontal tank | 34 |
| 11. | Experiment 9, horizontal tank | 34 |
| 12. | Experiment 10, horizontal tank | 35 |
| 13. | Experiment 11, horizontal tank | 36 |
| 14. | Experiment 12, horizontal tank | 37 |
| 15. | Experiment 13, horizontal tank | 38 |
| 16. | Experiment 14, horizontal tank | 38 |
| 17. | Experiment 15, horizontal tank | 39 |
| 18. | Experiment 16, horizontal tank | 39 |
| 19. | Experiment 17, horizontal tank | 40 |
| 20. | Experiment 18, horizontal tank | 40 |
| 21. | Vertical tank | 43 |
| 22. | Experiment No. 1 in vertical tank; contours for 12.10 p. m | 43 |
| 23. | Experiment No. 1 in vertical tank; contours for 12.40 p. m | 44 |
| 24. | Experiment No. 1 in vertical tank; contours for 1.40 p. m | 44 |
| 25. | Experiment No. 1 in vertical tank; contours for 2.40 p. m | 45 |
| 26. | Experiment No. 1 in vertical tank; contours for 3.40 p. m | 45 |

Page.
FIG. 27. Experiment No. 1 in vertical tank; contours for 4.40 p. m ..... 46
28. Experiment No. 2 in vertical tank; contours for 2.55 p. m..... 46
29. Experiment No. 2 in vertical tank; contours for 7.25 p. m..... 47
30. Variation in rate of flow of ground water with variation in head .... 48
31. Ampere curves at stations Nos. 1 and 2, Rio Hondo, California..... 52
32. Ampere curve at station No. 3, San Gabriel River, California..... 54
33. Map of gorge of Mohave River, Victorville, Cal..... 56
34. Cross section of gorge of Mohave River, Victorville, Cal..... 57
35. Plan of underflow station, gorge of Mohave River..... 57
36. Ampere curve at station A, Mohave River ..... 58
37. Ampere curve at station E, Mohave River, for depth of 8 feet ..... 58
38. Ampere curve at station E, Mohave River, for depth of 14 feet..... 59
39. Ampere curve at station E, Mohave River, for depth of 20 feet ..... 60
40. Ampere curve at station G, Mohave River, for depth of 25 feet..... 61
41. Ampere curve at station G, Mohave River, for depth of 30 feet..... 62
42. Ampere curve at station I, Mohave River, for depth of 24 feet ..... 62
43. Ampere curve at station 2 X, Long Island ..... 68
44. Ampere curves at station 5, Long Island..... 70
45. Ampere curve at station 6, Long Island..... 71
46. Ampere curve at station 7, Long Island..... 72
47. Ampere curve at station 8, Long Island..... 73
48. Ampere curve at station 10, Long Island..... 74
49. Ampere curve at station 12, Long Island..... 75
50. Ampere curve at station 14, Long Island..... 76
51. Ampere curve at station 15, Long Island..... 76
52. Ampere curve at station 15 X, Long Island ..... 77
53. Ampere curve at station 13, Long Island..... 78
54. Ampere curve at station 16 X, Long Island ..... 79
55. Ampere curve at station 17, Long Island..... 80
56. Ampere curve at station 21, Long Island..... 81
57. Map showing underflow stations, Long Island..... 82
58. Map showing stations 5 and 6, Long Island ..... 83
59. Map showing stations 2, 13, 16, 17, and Wantagh Pond, Long Island. 84
60. Apparatus for measuring rate of rise of water in wells ..... 90
61. Curves of rise of water in wells..... 94
62. Roller perforator for stovepipe wells..... 100
63. Plan and elevation of California well-rig derrick ..... 102
64. Conditions at pumping plant of Felix Martinez, near El Paso, Tex .. 105
65. Conditions at pumping plant of J. A. Smith, near El Paso, Tex ..... 107
66. Conditions at pumping plant of Theodore Roualt, near Las Cruces, N. Mex..... 110
67. Conditions at Horaco Ranch Company's well No. 1, at Berino, N. Mex..... 111

# LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
*Washington, D. C., August 10, 1904.*

SIR: I transmit herewith, for publication, a manuscript entitled "Field Measurements of the Rate of Movement of Underground Waters," prepared by Prof. Charles S. Slichter, professor of mathematics, University of Wisconsin.

The paper presents an amplified exposition of the method of measuring the movement of underground waters which was devised by Professor Slichter in 1901 while working for the hydrographic branch of the United States Geological Survey and which has been already briefly described in Water-Supply Paper No. 67, 1902. Descriptions of the apparatus invented by him for the laboratory study of wells controlling horizontal and vertical movements of underground waters and the results of these studies are also presented. The laboratory studies are also supplemented by detailed accounts of several investigations made in the field.

This paper should be interesting and valuable to engineers and geologists, and the direct application of the results to the study of problems of vital interest to the users of artesian waters should be of great practical value to the general public. A very suggestive and interesting description of the California method of sinking "stovepipe" wells deserves the attention of drillers in unconsolidated deposits throughout our country, while the description of the carefully made tests on typical pumping plants in Texas and New Mexico should appeal to engineers and others who are interested in the problem of raising water for irrigation or other purposes.

Very respectfully,

F. H. NEWELL,
*Chief Engineer.*

Hon. CHARLES D. WALCOTT,
*Director United States Geological Survey.*

# FIELD MEASUREMENTS OF THE RATE OF MOVEMENT OF UNDERGROUND WATERS.

By CHARLES S. SLICHTER.

## INTRODUCTION.

The following paper describes the method and apparatus used in measuring the velocity of underground waters and gives the results of field work done with the apparatus in various parts of the United States, under authority of the hydrographic branch of the United States Geological Survey. The method used in making the measurements was devised by the writer after preliminary tests along the Arkansas River in western Kansas during the summer of 1901. This preliminary work indicated that it was practicable to measure the rate of flow of ground waters by the use of very simple apparatus. Several determinations of the rate of movement of the underflow of the Arkansas were made during that summer. These measurements, it is believed, constituted the first direct determinations of the rate of flow of ground water that had been made in this country. This preliminary work was done in the neighborhood of Dodge, Kans., and at one or two points near Garden, Kans. The photographs reproduced in Pl. I show the locations of the first successful stations, which were established near Garden, Kans. A brief description of the electrical method of measuring the velocities of underground waters resulting from this preliminary investigation was printed in the Engineering News of February 20, 1902, and in paper No. 67 of the Water-Supply and Irrigation series of the United States Geological Survey. Since then, as the result of work carried on in the field and in the laboratory, the apparatus has been gradually improved, and its present form is described in these pages.

The paper will also include some determinations of the manner and rate of flow of water into tubular wells, and descriptions of methods and simple apparatus designed to accurately estimate the capacity of such wells.

# CHAPTER I.

## THE CAPACITY OF A SAND TO TRANSMIT WATER.

### FACTORS INFLUENCING FLOW.

The general laws governing the flow of water through a mass of sand or gravel have been described by the writer in another paper.[a] and will not be repeated in this place. It is sufficient to state that experiments show that the flow of water in a given direction through a column of sand is proportional to the difference in pressure at the ends of the column, and inversely proportional to the length of the column, and is also dependent upon another factor, called the transmission constant of the sand.

### TRANSMISSION CONSTANT.

The resistance offered by sand or gravel to the flow of water which is percolating through it is very great. The water is obliged to pass through very small pores, usually capillary in character; indeed, they are much smaller in cross section than the soil particles between which they pass. If the particles of sand or gravel which make up the water-bearing medium are well rounded in form the pores are somewhat triangular in cross section and the diameter of the individual pores is only one-fourth to one-seventh the diameter of the soil particles themselves. Thus if the individual grains of sand average 1 millimeter in diameter the pores through which the water must pass will average only one-fourth to one-seventh of a millimeter in diameter. If to a mass of nearly uniform sand particles larger particles be added the effect on the resistance to the flow of water will be one of two kinds, depending principally upon the ratio which the size of the particles added bears to the average size of grains in the original sand. If the particles added are only slightly larger than the original sand grains, the effect is to increase the capacity of the sand to transmit water, and the more particles of this kind that are added the greater will be the increase in the capacity of the sand to transmit water. If, however, large particles are added, the effect is the reverse. If particles seven to ten times the diameter of the original sand grains be added, each of the new particles tends to block the course of the

[a] The motions of underground waters: Water-Sup. and Irr. Paper No. 67, U. S. Geol. Survey, 1902.

*A*

*B*

LOCATION OF FIRST UNDERFLOW STATIONS, AUGUST, 1901, NEAR GARDEN, KANS.

*A*, Station 1, near Point of Rock; *B*, Station 2, south of island.

water. Thus, for example, a large bowlder placed in a mass of fine sand will tend to block the passage of the water. As more and more of the large particles are added to a mass of uniform sand, the rate of flow of water through it will be decreased until the amount of the large particles equals about 30 per cent of the total mass. From this time on the adding of the large particles will increase the capacity of the whole to transmit water until, if a very large quantity of the large particles be added, so that the original mass of fine particles becomes relatively negligible, the capacity to transmit will approach that of the mass of the large particles alone. These facts have an important bearing upon the capacity of gravels to furnish water to wells or to transmit water in the underflow of a river. The presence of large particles is not necessarily to be interpreted as indicating a high transmission capacity of the material, for this is indicated only when the large particles constitute a large fractional per cent of the total mass, as would be the case where the large particles equal 40 or 50 per cent of the whole.

The capacity of any sand or gravel to transmit water can be expressed by means of a single number which is called the transmission constant of the soil. This constant is defined to be the amount of water transmitted in unit time through a cylinder of the soil of unit length and unit cross section under unit difference in head at the ends. For example, if the foot and minute be the units of length and time, and if a column of sand 1 square foot in cross section and 1 foot in length will transmit 1 cubic foot of water a minute under a difference in head of 1 foot of water, the transmission constant is 1. The transmission constant of a soil varies very greatly with the size of the individual grains constituting the sand or gravel, and also depends in a marked degree upon the porosity or amount of open space in the soil. Table I, herewith, gives the transmission constants for a variety of sizes of soil grain and for a series of porosities varying from 30 to 40 per cent. This table is computed for a temperature of the water of 60° F. An auxiliary table, Table II, is one from which the transmission constants corresponding to other temperatures can readily be found.

Transmission constant $k$ is the quantity of water, measured in cubic feet, that is transmitted in one minute through a cylinder of the soil 1 foot in length and 1 square foot in cross section, under difference in head at the ends of 1 foot of water.

The tabulated numbers express the transmission constant in cubic feet per minute.

TABLE I.—*Transmission constants from which the velocity of water in sands of various effective sizes of grain can be obtained.*

Table computed for temperature of 60° F.; results for other temperatures can be found by the use of Table II.]

| Diameter of soil grain in mm. | Porosity. | | | | | | Kind of soil. |
|---|---|---|---|---|---|---|---|
| | 30 per cent. | 32 per cent. | 34 per cent. | 36 per cent. | 38 per cent. | 40 per cent. | |
| 0.01 | 0.000033 | 0.000040 | 0.000050 | 0.000060 | 0.000072 | 0.000085 | Silt. |
| .02 | .000131 | .000162 | .000198 | .000239 | .000286 | .000339 | |
| .03 | .000296 | .000364 | .0004460 | .000538 | .000645 | .000763 | |
| .04 | .000527 | .000648 | .0007940 | .000958 | .001145 | .001355 | |
| .05 | .000822 | .001012 | .001240 | .001495 | .001790 | .002120 | Very fine sand. |
| .06 | .001182 | .001458 | .001784 | .002150 | .002580 | .003050 | |
| .07 | .001610 | .001983 | .002430 | .002930 | .003510 | .004155 | |
| .08 | .002105 | .002590 | .003175 | .003825 | .004585 | .005425 | |
| .09 | .002660 | .003280 | .004018 | .004845 | .005800 | .006860 | |
| .10 | .003282 | .004050 | .004960 | .005980 | .007170 | .008480 | Fine sand. |
| .12 | .004725 | .005830 | .007130 | .008620 | .01032 | .01220 | |
| .14 | .006430 | .007940 | .009720 | .01172 | .01404 | .01662 | |
| .15 | .007390 | .009120 | .01115 | .01345 | .01611 | .01910 | |
| .16 | .008410 | .01036 | .01268 | .01531 | .01835 | .02170 | |
| .18 | .01064 | .01311 | .01605 | .01940 | .02320 | .02745 | |
| .20 | .01315 | .01620 | .01983 | .02390 | .02865 | .03390 | |
| .25 | .02050 | .02530 | .03100 | .03740 | .04480 | .05300 | Medium sand. |
| .30 | .02960 | .03640 | .04460 | .05380 | .06450 | .07630 | |
| .35 | .04025 | .04960 | .06075 | .07330 | .08790 | .01039 | |
| .40 | .05270 | .06480 | .07940 | .09575 | .1145 | .1355 | |
| .45 | .06650 | .08200 | .1005 | .1211 | .1450 | .1718 | |
| 50 | .08220 | .1012 | .1240 | .1495 | .1780 | .2120 | Coarse sand. |
| .55 | .09940 | .1225 | .1500 | .1810 | .2165 | .2565 | |
| .60 | .1182 | .1458 | .1784 | .2150 | .2580 | .3050 | |
| .65 | .1390 | .1710 | .2095 | .2530 | .3030 | .3580 | |
| .70 | .1610 | .1983 | .2430 | .2930 | .3510 | .4155 | |
| .75 | .1850 | .2278 | .2785 | .3365 | .4030 | .4770 | |
| .80 | .2105 | .2590 | .3175 | .3825 | .4585 | .5425 | |
| .85 | .2375 | .2925 | .3580 | .4325 | .5175 | .6125 | |
| .90 | .2660 | .3280 | .4018 | .4845 | .5800 | .6860 | |
| .95 | .2965 | .3650 | .4470 | .5400 | .6460 | .7650 | |
| 1.00 | .3282 | .4050 | .4960 | .5980 | .7170 | .8480 | Fine gravel. |
| 2.00 | 1.315 | 1.620 | 1.983 | 2.390 | 2.865 | 3.390 | |
| 3.00 | 2.960 | 3.640 | 4.460 | 5.380 | 6.450 | 7.630 | |
| 4.00 | 5.270 | 6.480 | 7.940 | 9.575 | 11.45 | 13.55 | |
| 5.00 | 8.220 | 10.12 | 12.40 | 14.95 | 17.90 | 21.20 | |

TABLE II.—*Variation, with the temperature, of the flow of water of various temperatures through a sand, 60° F. being taken as the standard temperature.*

| Temperature. | Relative flow.[a] | Temperature. | Relative flow.[a] |
|---|---|---|---|
| *° F.* | *Per cent.* | *° F.* | *Per cent.* |
| 32 | 0.64 | 70 | 1.15 |
| 35 | .67 | 75 | 1.23 |
| 40 | .73 | 80 | 1.30 |
| 45 | .80 | 85 | 1.39 |
| 50 | .86 | 90 | 1.47 |
| 55 | .93 | 95 | 1.55 |
| 60 | 1.00 | 100 | 1.64 |
| 65 | 1.08 | | |

[a] "Relative flow" means flow at given temperature compared with flow at 60° F. It is expressed as a percentage.

It should be borne well in mind that the rate of transmission varies very greatly with the temperature of the water. For example, a change from 50° to 60° increases the capacity to transmit water under identical conditions by about 16 per cent, while a change from the freezing temperature to a temperature of 75° will nearly double the power of a soil to transmit water. This difference, of course, is not due to any change in the soil itself, but is due solely to the increased ease with which water flows at high temperatures compared to the ease with which it flows at low temperatures. The transmission constant of a sand can also be obtained by use of the diagram given in Pl. II. Graduated vertical lines will be found in this diagram corresponding to the diameter of the soil grains ($d$), the amount of water transmitted ($q$), the hydraulic gradient ($s$), and the porosity of the soil ($m$). The graduated line marked $U$ is an auxiliary scale. The number $d$ is expressed in millimeters, and $q$ is expressed in cubic feet per minute. The hydraulic gradient $s$ is expressed as a percentage. A slope of the ground water equal to 2 feet in 100 feet appears in the diagram as hydraulic gradient 0.02 and a slope of 528 feet per mile appears as 0.10. The porosity, $m$, also appears in the diagram as a percentage. The porosity or amount of voids in a sand will usually lie between 25 and 46 per cent of the total volume.

The diagram is used as follows: Suppose that the amount of water transmitted by a sand per square foot of cross section is desired, if the effective size of soil grain is 0.55 millimeter, the hydraulic gradient 2 feet in 100 feet, and the porosity is 36 per cent. Apply a ruler or straight edge (the edge of a piece of letter paper will do) to the diagram, passing through the mark 0.55 on $d$ and the mark 0.02 on $s$. The edge of the ruler will locate a point 0.47 on $U$, the exact location

of which should be noted. Then move the ruler so that it will pass through this same point on $U$ and through the mark 36 on $m$. The place where the ruler crosses the line $q$ (0.0036), will give the discharge in cubic feet per minute. The diagram gives results based upon the assumed temperature of the water of 60° F.[a]

If any three of the four magnitudes $d$, $q$, $s$, $m$ are known, the remaining one can be found in a manner similar to the above.

The removal of larger particles from a mixed sand may not only increase the transmission constant in the manner described above, but such removal may also increase the transmission capacity by permitting the remaining sand to pack in a more open manner, as would be shown by an increased porosity. Tables II and III give results which show that the removal of the larger grains from a sand does not necessarily decrease the transmission constant, but may even increase it. The results given in Table III were obtained by successively removing the larger particles from a mass of sand by means of standard sieves, and then determining the porosity, effective size,[b] and transmission constant for the finer material passing through the successive sieves. The gravel represented by Table III consisted of a mixture of all sizes of grains, from very fine grains to bowlders 2 feet in diameter. All pieces larger than 1 inch in diameter were discarded before the results shown in Table III were obtained. It is interesting to note that the 93.4 per cent of the total sand passing through sieve 2 (2 meshes to the inch) did not have as large an effective size as the 74.2 per cent which passed through sieve 20 (20 meshes to the inch).

Table III is derived from a beach sand. The 54.3 per cent of this sand which passed through sieve 10 has a smaller transmission constant than the 36.8 per cent which passed through sieve 14.

The following table shows the effect of removing, by means of standard sieves, the coarser portions of a natural Arizona gravel. The data in columns 2, 3, 4, 5, and 6 apply to that portion of original sample that passed the sieve named in column 1.

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[a] The diagram was computed and drawn for the writer by J. D. Suter, of the University of Wisconsin.

[b] The *effective size* of a sample of sand is such a number that if all grains were of that diameter the sand would have the same transmission capacity that it actually has. It is, therefore, the true mean or average size of sand grain in that sample.

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TABLE III.—*Effect of removing coarser portions of field gravel.*

| 1. No. of sieve. | 2. Quantity of gravel passing. | 3. Differences of numbers in column 2. | 4. Porosity of portion passing. | 5. Effective size. | 6. Transmission constant at 80°F. |
|---|---|---|---|---|---|
| *Meshes to inch.* | *Per cent of total weight.* | *Per cent of total weight.* | *Per cent.* | *Mm.* | *Cubic feet per minute.* |
| 2 | 93.4 | 6.6 | 38.1 | 0.325 | 0.102 |
| 8 | No data. | ..... | 40.0 | .320 | .120 |
| 10 | 83.7 | 9.7 | 38.6 | .282 | .080 |
| 12 | 82.6 | 1.1 | 40.3 | .304 | .108 |
| 14 | 80.3 | 2.3 | 39.5 | .282 | .086 |
| 16 | 78.0 | 2.3 | 39.7 | .282 | .088 |
| 18 | 76.4 | 1.6 | 39.6 | .277 | .085 |
| 20 | 74.2 | 2.2 | 40.6 | .317 | .119 |
| 30 | 55.9 | 8.3 | 41.0 | .250 | .076 |
| 40 | 32.2 | 23.7 | 40.6 | .187 | .042 |

The following table shows the effect of removing by means of standard sieves the coarser portions of a natural beach gravel. The data in columns 2, 3, 4, 5, and 6 apply to that portion of original sample that passed sieve named in column 1.

TABLE IV.—*Effect of removing coarser portions of a beach gravel.*

| 1. No. of sieve. | 2. Quantity of gravel passing. | 3. Differences of numbers in column 2. | 4. Porosity of portion passing. | 5. Effective size. | 6. Transmission constant at 72°F. |
|---|---|---|---|---|---|
| *Meshes to inch.* | *Per cent of total weight.* | *Per cent of total weight.* | *Per cent.* | *Mm.* | *Cubic feet per minute.* |
| Total sample. | 100.0 | ..... | 37.8 | 0.810 | 0.529 |
| 10..... | 54.3 | 45.7 | 40.0 | .634 | .390 |
| 12..... | 47.6 | 6.7 | 41.7 | .640 | .457 |
| 14..... | 36.8 | 10.8 | 41.7 | .603 | .406 |
| 16..... | 31.4 | 5.4 | 42.6 | .539 | .348 |
| 18..... | No data. | ..... | 43.5 | .520 | .348 |
| 20..... | 25.6 | 5.8 | 43.5 | .494 | .314 |

# CHAPTER II.

## UNDERFLOW METER USED IN MEASURING VELOCITY AND DIRECTION OF MOVEMENT OF UNDERGROUND WATERS.

### TYPES OF APPARATUS.

The apparatus used is of two types: (1) Direct reading, or hand apparatus, requiring the personal presence of the operator every hour for reading of instruments, and (2) recording apparatus, which requires attention but once in a day. Both forms are described in this chapter. The arrangement of the test wells and manner of wiring the wells is essentially the same for both.

### TEST WELLS.

The test wells suitable for use with the underflow meter in determining the velocity of ground waters may be common 1½-inch or 2-inch drive wells if the soil is easily penetrated and if the depths to be reached do not exceed 50 to 75 feet. For greater depths and harder soil wells of heavy construction should be used. The 1½-inch drive wells are much preferable to the 1¼-inch wells because of the fact that 1½-inch pipe is lap welded, while the 1¼-inch is butt welded, and less capable of standing severe pounding. The drive point used with the well may be 1½-inch standard brass jacket well points, 42 to 48 inches long, with No. 60 brass gauze strainer. The well points should be threaded with 1½ inches of standard thread, somewhat more than is usually found on the trade goods. The pipe should be full weight strictly wrought-iron standard pipe, cut in lengths of 6 or 7 feet, and threaded 1½ inches at each end. The couplings should be wrought-iron hydraulic recessed couplings, and the thread on the pipe should be cut in such a way that when properly screwed up the ends of the pipe will abut. The recessed couplings protect the pipe at its weakest point, while an ordinary coupling will leave exposed a thread or two of the pipe so that severe driving is liable to swell and ultimately rupture the pipe just above the coupling. Fig. 1 represents a hydraulic coupling, showing a properly made joint.

The driving head should be made of rolled steel shafting and should be about 4 inches long, carrying 1½-inches standard thread and an air hole to permit the free escape of air from the well while the driving

is in progress. A driving ram for putting down the drive wells should be about 5½ feet long by 5½ inches in diameter, made of heavy oak or other tough wood, with iron bands shrunk on the ends, and bearing two handles of hard wood at each end in order to facilitate the handling of the ram by two men. It is convenient to have these handles placed one about 1 foot from one end, and the other about 2 feet from the other end. By reversing the ram the handles are brought in a more convenient position for driving as the well goes down.

Pl. III, *A* illustrates the method of putting down drive points. If the test wells are to be sunk to a depth exceeding that to which drive points can be readily driven, open-end 2-inch pipe should be used. These wells should be made with full weight strictly wrought-iron 2-inch pipe with long threads and recessed hydraulic couplings, as described above. The pipe can either be put down without a screen, in which case a 1¼-inch well point with turned coupling may be inserted through a drive shoe at the bottom of the casing after the pipe is

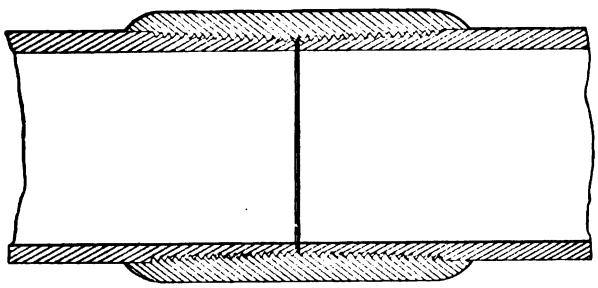


FIG. 1.—Pipe joint made with hydraulic coupling. This joint will stand hard driving.

driven into place, or an open-end brass jacket well point, 48 inches long, may be put down with the pipe. The pipe should be driven into place with a cast-iron ram varying in weight from 150 to 250 pounds, simultaneously hydraulicking a passage for pipe with water jet in three-fourths-inch wash pipe. There are many hand rigs on the market suitable for this work, or a rig can be readily constructed by any good mechanic. Such a rig is shown in Pl. VI, *A*. A suitable pump for the hydraulic jet is a double-acting horizontal force pump with a 4- by 4½-inch cylinder. If the material in which the well is to be drilled is not too hard nor too full of bowlders, the writer recommends that an open-end well point be put down with the casing. This is apt to cause some difficulty in the proper working of the hydraulic jet, by the escape of water through the screen of the well point. This difficulty can be obviated and a more powerful wash secured by admitting a considerable quantity of air along with the water at the suction end of the force pump. The exact amount of air to be admitted can

be readily determined with a little experience. The effect of the air entering the well under high pressure is to form a powerful air lift which will throw the water and gravel out of the top of the well casing with great force. It has been the writer's experience that the best hydraulic samples are obtained with the combination hydraulic pneumatic jet. If the hydraulic jet alone is used the coarser particles have a tendency to remain at the bottom of the well.

After a test is completed the well casing can readily be pulled by a No. 2 cast-iron pipe puller and two 5-ton railroad jacks. Sets of dies for the pipe puller to fit both 1½- and 2-inch pipe can be obtained at small cost. Pl. III, *B*, shows the operation of the pipe puller and railroad jacks.

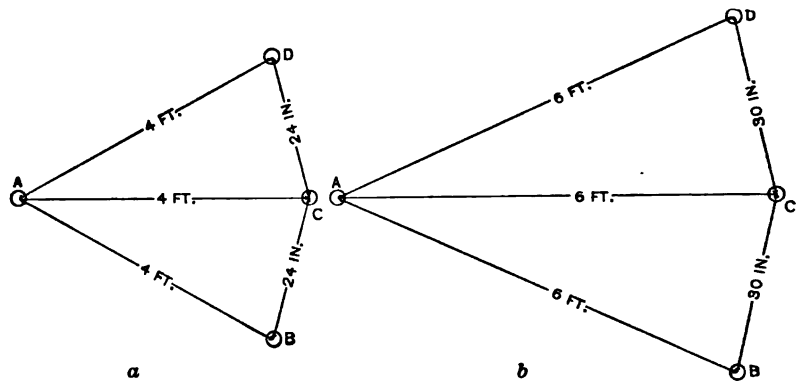
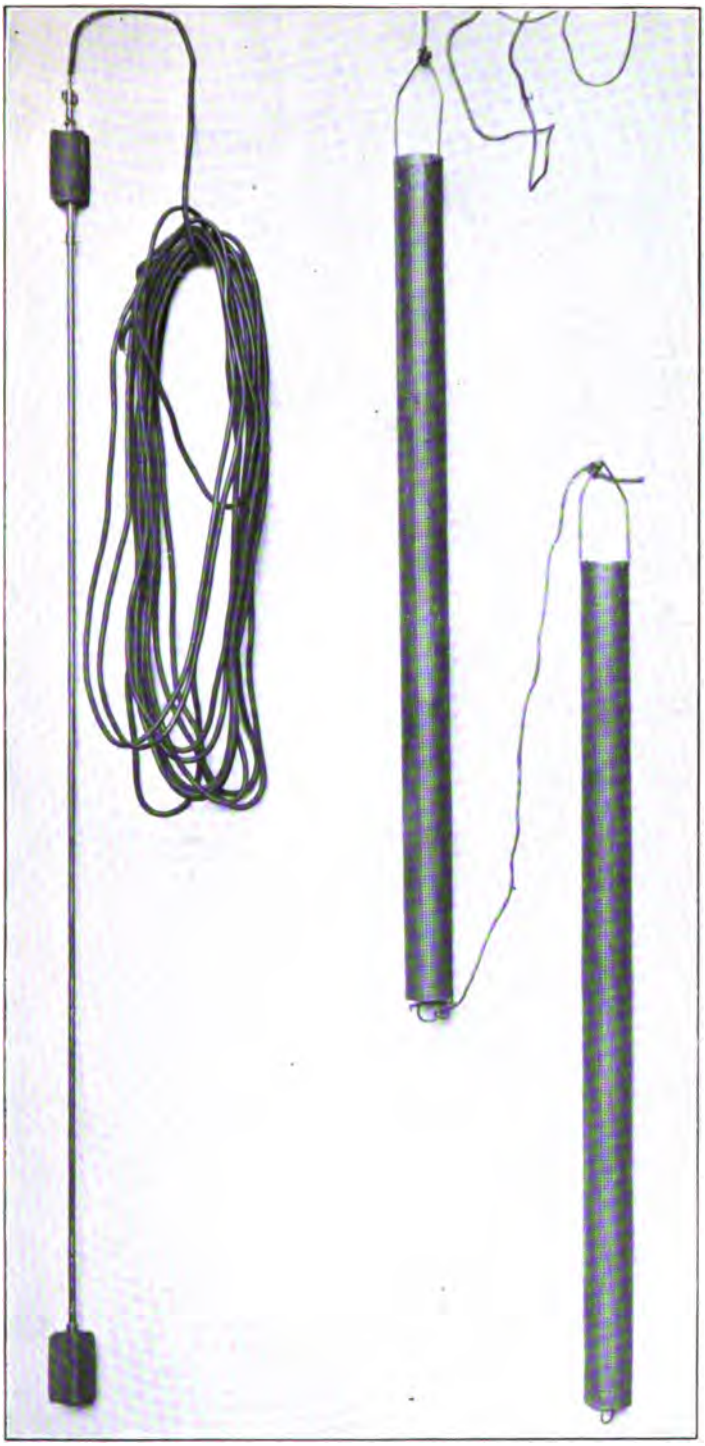



FIG. 2.—Plan of arrangement of test wells used in determining the velocity and direction of motion of ground water: A, B, C, D are the test wells. The direction A–C is the direction of probable motion of the ground water. The dimensions given in plan *a* are suitable for depths up to about 25 or 30 feet, those in plan *b* for depths up to about 75 feet. For greater depths the distances A–B, A–C, A–D should be increased to 9 or 10 feet, and the distances B–C and C–D to 4 feet. The well A is the "salt well" or well into which the electrolyte is placed.

The test wells are driven in groups, as shown in fig. 2, each group of wells constituting a single station for the measurement of the direction and rate of flow of the ground water. In case the wells are not driven deeper than 25 feet, the "upstream" or "salt well" A is located, and three other wells, B, C, and D, are driven at a distance of 4 feet from A, the distance between B and C and C and D being about 2 feet. The well C is located so that the line from A to C will coincide with the probable direction of the expected ground-water movement. This direction should coincide, of course, with the local slope of the water plane, and if this is not accurately known, it should be determined by means of leveling with a level. For deeper work the wells should be located farther apart, as shown in the right portion of fig. 2. For depths exceeding 75 feet, a radius of 8 or 9 feet and chords of 4 feet should be used, the general requirement being that the wells should be as close together as possible, so as to cut down to

*A.* RAM USED FOR DRIVING SMALL WELLS BY HAND.

*B.* PULLING WELL CASING WITH RAILROAD JACK AND NO. 2 PIPE PULLER.



ELECTRODE AND PERFORATED BRASS BUCKETS USED IN CHARGING WELLS.

a minimum the time required for a single measurement, but not so close that important errors are liable to be introduced by the inability to drive the wells perfectly straight and plumb. On this account the deeper the wells the farther apart they should be placed. The angles B A C and C A D should not exceed 30°.

## DIRECT-READING INSTRUMENTS.

Electrical connection is made with the casing of each test well by means of a drilled coupling carrying a binding post. Each of the downstream wells (B, C, D) contains within the well point or screen section an electrode consisting of a nickeled brass rod three-eighths inch in diameter by 4 feet long, insulated from the casing by wooden spools. The end of rod receives a No. 14 rubber-covered wire, to which good contact is made by a chuck clutch. An electrode is shown in Pl. IV. This electrode communicates with the surface by means of a rubber-covered copper wire. Pl. IV also shows two buckets of perforated brass used in charging wells with granulated sal ammoniac; each is 1¾ by 30 inches.

Fig. 3 illustrates the arrangement of electric circuits between the upstream well and one of the downstream wells. Each of the downstream wells is connected to the upstream well in the manner shown in this figure.

A view of the direct-reading underflow meter is shown in Pl. V, *A*. Six standard dry cells are contained in the bottom of the box, their poles being connected to the six switches shown at the rear of the case. By means of these switches any number of the six cells may be thrown into the circuit in series. One side of the circuit terminates in eight press keys, shown at the left end of the box. The other side of the circuit passes through an ammeter, shown in the center of the box, to two three-way switches at right end of the box. Four of the binding posts at the left end of the box are connected, respectively, to the casing of well A, and to the three electrodes of wells B, C, and D, in the order named. The binding posts at the right end of the box are connected to the casings of wells B, C, and D. There are enough binding posts to connect two different groups of wells to the same instrument. When the three-way switch occupies the position shown in the photograph, pressing the first key at left end of the box will cause the ammeter to show the amount of current passing between casing of well A and casing of well B. When the next key is pressed the ammeter will indicate the current between the casing of well B and the electrode contained within it. In one instance the current is conducted between the two well casings by means of the ground water in the soil; in the second case the electric circuit is completed by means of the water within well B. By putting the three-way switch in second position and pressing the first and third

keys in turn, similar readings can be had for current between casings A and C and between casing C and its internal electrode. Similarly with switch in third position, readings are taken by pressing first and fourth keys. The results may be entered in a notebook, as shown in Table V.

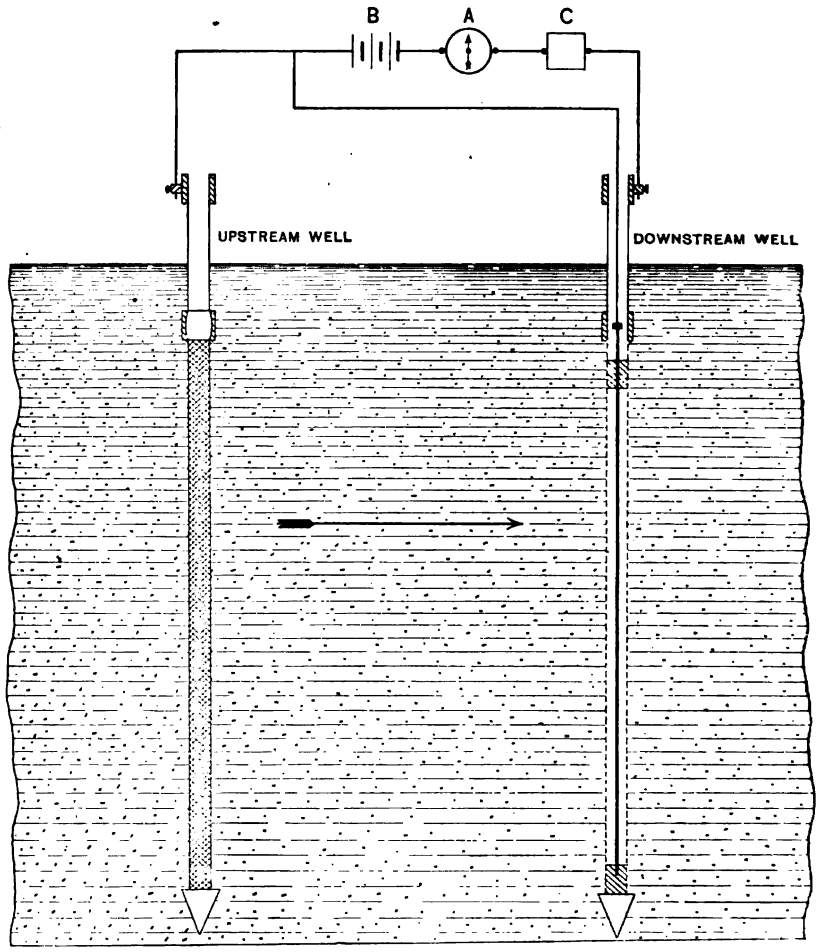



FIG. 3.—Diagram illustrating electrical method of determining the velocity of flow of ground water. The ground water is supposed to be moving in the direction of the arrow. The upstream well is charged with an electrolyte. The gradual motion of the ground water toward the lower well and its final arrival at that well are registered by the ammeter A B is the battery and C a commutator clock which is used when A is a recording ammeter.

The principles involved in the working of the apparatus are very simple. The upstream well A is charged with a strong electrolyte, such as sal ammoniac, which passes down stream with the moving ground water, rendering the ground water a good electrolytic conductor of electricity. If the ground water moves in the direction of one of the lower wells, B, C, D, etc., the electric current between

*A* UNDERFLOW METER, SHOWING CONNECTIONS WHEN USED AS DIRECT-READING APPARATUS.

When used with recording ammeter, only two connections are made, one to each side of battery circuit; but the ammeter is left in circuit with the recording instrument to indicate whether the latter is working properly.

*B*. COMMUTATOR CLOCK, FOR USE WITH RECORDING AMMETER.

The clock makes electrical contact at any five-minute interval.

A and B, A and C, or A and D will gradually rise, mounting rapidly when the electrolyte begins to touch one of the lower wells. When the electrolyte finally reaches and enters inside of one of the wells B, C, D, it forms a short circuit between the casing of the well and the internal electrode, causing an abrupt rise in the electric current. The result can be easily understood by consulting Table V and fig. 4, in which the current is depicted graphically.

TABLE V.—*Field record of electric current during underflow measurements at station 5, Rio Hondo and San Gabriel River, California, August 5 and 6, 1902.*

[Readings in ampères and decimals of an ampère.]

| Time. | Well B. | | Well C. | | Well D. | | Remarks.[a] | |
|---|---|---|---|---|---|---|---|---|
| | Casing. | Electrode. | Casing. | Electrode. | Casing. | Electrode. | | |
| 8 a. m | 0.140 | 0.360 | 0.142 | 0.332 | 0.150 | 0.390 | ..... | ..... |
| 8.15 a. m | Salt. | ..... | Salt. | ..... | Salt. | ..... | 1 NaCl | 2 $NH_4Cl$ |
| 8.30 a. m | .160 | ..... | .163 | ..... | .170 | ..... | ..... | 1 $NH_4Cl$ |
| 9 a. m | .168 | ..... | .170 | ..... | .180 | ..... | 1 NaCl | ..... |
| 10 a. m | .180 | .360 | .182 | .330 | .192 | .390 | ..... | 1 $NH_4Cl$ |
| 11.40 a. m | .192 | .345 | .195 | .325 | .202 | .380 | ..... | ..... |
| 1 p. m | .202 | .340 | .202 | .320 | .210 | .370 | ..... | 1 $NH_4Cl$ |
| 2 p. m | .205 | .345 | .204 | .340 | .210 | .370 | ..... | ..... |
| 3 p. m | .208 | .342 | .205 | .320 | .210 | .360 | 1 NaCl | ..... |
| 4 p. m | .210 | .350 | .205 | .320 | .210 | .370 | ..... | ..... |
| 5 p. m | .218 | .330 | .210 | .310 | .212 | .360 | ..... | 1 $NH_4Cl$ |
| 6 p. m | .225 | .330 | .210 | .310 | .218 | .360 | ..... | ..... |
| 7 p. m | .230 | .330 | .218 | .310 | .220 | .360 | ..... | ..... |
| 8 p. m | .240 | .330 | .222 | .310 | .223 | .350 | 1 NaCl | ..... |
| 9 p. m | .250 | .330 | .222 | .320 | .225 | .352 | ..... | ..... |
| 10.30 p. m | .275 | .340 | .225 | .315 | .225 | .360 | ..... | ..... |
| 12 p. m | .350 | .600 | .230 | .310 | .230 | .340 | ..... | 1 $NH_4Cl$ |
| 1 a. m [b] | .420 | .850 | .240 | .310 | .230 | .340 | ..... | ..... |
| 2.30 a. m | .510 | 1.550 | .240 | .310 | .230 | .340 | ..... | ..... |
| 4.15 a. m | .560 | 2.000 | .240 | .310 | .230 | .340 | ..... | ..... |
| 5.30 a. m | .550 | 2.200 | .230 | .310 | .230 | .330 | ..... | ..... |
| 7.45 a. m | .520 | 2.250 | .230 | .310 | .225 | .330 | ..... | ..... |
| 8.15 a. m | ..... | 2.250 | ..... | ..... | ..... | ..... | ..... | ..... |
| 9 a. m | ..... | 2.200 | ..... | ..... | ..... | ..... | ..... | ..... |

[a] The electrolyte was lowered into well A by means of a perforated brass bucket, 1¾ by 30 inches in size. The formula "2 $NH_4Cl$" means that two of these buckets, full of ammonium chloride, were introduced into well A at the time indicated. Each of these buckets held 2 pounds of the salt.
[b] August 6.

The time that elapses from the charging of the well A to the arrival of the electrolyte at the lower well gives the time necessary for the ground water to cover the distance between these two wells. Hence,

if the distance between the wells be divided by this lapse of time, the result will be the velocity of the ground water. The electrolyte does not appear at one of the downstream wells with very great abruptness: its appearance there is somewhat gradual, as shown in the curves in

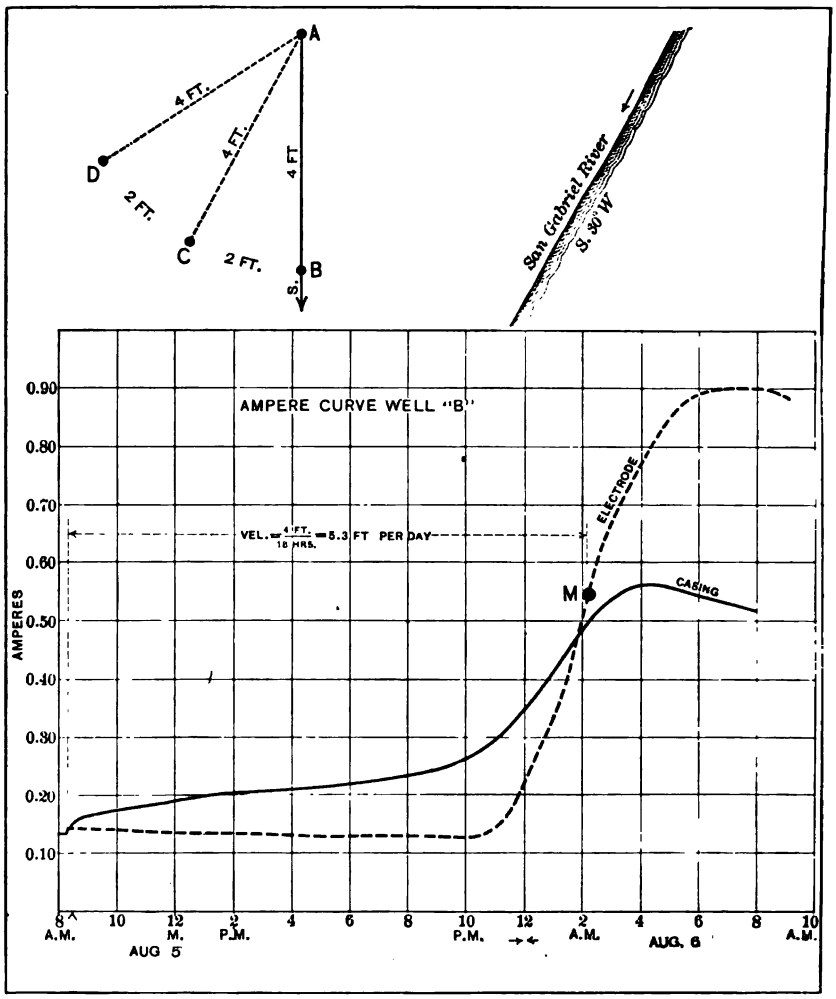



FIG. 4.—Diagram showing ampère curves at station 5 in the narrows of the San Gabriel River, California. The heavy curve represents the strength of electric current between the casing of well A and casing of well B. The dotted curve represents the strength of current between the electrode in well B and the casing of well B. These curves illustrate results obtained with the direct-reading form of apparatus.

figs. 4 and 5. The time required for the electrolyte to reach its maximum strength in one of the downstream wells (and hence, for the current to reach its maximum value) may vary from a few minutes in a case of high ground-water velocity to several hours in a case of low velocity. The writer formerly supposed that the gradual appearance

of the electrolyte at the downstream well was largely due to the diffusion of the dissolved salt, but it is now evident that diffusion plays but a small part in the result. The principal cause of the phenomena is now known to be due to the fact that the central thread of water in each capillary pore of the soil moves faster than the water at the walls of the capillary pore, just as the water near the central line of a river channel usually flows faster than the water near the banks. For this reason, if the water of a river suddenly be made muddy at a certain upstream point the muddy character of the water at a downstream point will appear somewhat gradually, being first brought down by the rapidly moving water in the center of the channel, and later by the more slowly moving water near the banks. The effect of the analogous gradual rise in the electrolyte in the downstream well requires us to select the "point of inflection" of the curve of electric current as the proper point to determine the true time at which the arrival of the electrolyte should be counted. This point is designated by the letter M in figs. 4 and 5.

Owing to the repeated branching and subdivision of the capillary pores around the grains of the sand or gravel, the stream of electrolyte issuing from the well will gradually broaden as it passes downstream. The actual width of this charged water varies somewhat with the velocity of the ground water, but in no case is the rate of the divergence very great. The manner in which the electrolyte spreads has been carefully investigated and will be described in a later page.

It is possible to dispense with the circuit between the casing of well A and the casing of each of the other wells, as the short circuit between the well and electrode forms the best possible indication of the arrival of the electrolyte at the downstream well. For cases in which the velocity of ground water is high, the circuit to well A is practically of no value; but for slow motions this circuit shows a rising current before the arrival of the electrolyte at the lower well, often giving indications of much value to the observer.

The method can be used successfully even though nothing but common pipe be used for the wells. In this case, however, the absence of screen or perforations in the wells renders the internal electrodes useless, and one must depend upon the circuit from well casing of the upstream well to well casing of downstream well.

The results shown in fig. 5 present such a case. In this case the wells were not provided with well points, but merely possessed a 4-foot length of pipe, provided with four or five holes on opposite sides of the pipe containing small ½-inch washer screens. These few openings are not sufficient to permit the electrolyte to enter the well freely, so that readings between casings were relied upon for results. As a matter of fact, enough of the electrolyte did get into the well to give small increased readings, but in order to obtain the electrode readings

shown in the diagram water was removed from the downstream wells by a small bucket holding about 6 ounces, so as to force a quantity of the water surrounding the well into the perforated sections. In cases where good well points are used the ground water charged with the electrolyte finds its way gradually and naturally into the well. The well point should be clear enough to allow as free passage into the well as through the soil itself. This is easily accomplished by pumping water from each test well with a common pitcher pump for a few minutes or until the water is fairly clear.

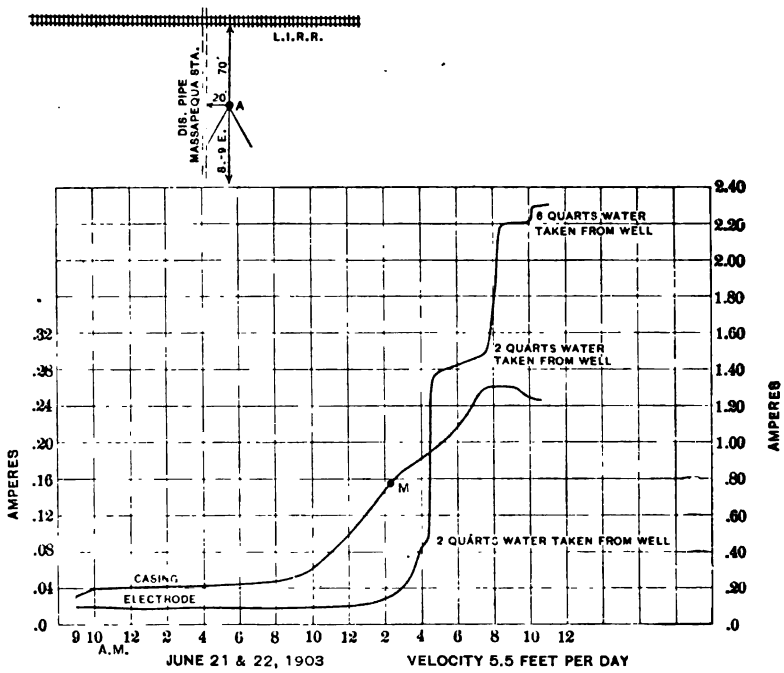



FIG. 5.—Ampere curves at station 1, Long Island, N. Y., showing possibility of use of direct-reading apparatus when well points are not used. The casing in this instance consisted of common black 2-inch pipe, with a few small holes in bottom section. The "casing" curve must be relied upon for determining velocity. The "electrode" curve was obtained by drawing water from well C, as shown on diagram, the charged water being drawn into the well through the small holes and the open end of well.

Granulated sal ammoniac is used to dose well A. A single charge may vary from 4 to 10 pounds. If common pipe without points or screen is used for the wells, so that internal electrodes must be dispensed with, doses of about 2 pounds each should be repeated about every hour. The dry salt should not be poured directly into the well, but should be lowered in perforated buckets, a photograph of one being shown in Pl. IV. These buckets are 1¾ by 30 inches and hold about 2 pounds of the salt. Two of these buckets may be tied one above the other for the initial charge, and followed by two more in ten or twenty minutes.

If the wells are not too deep, the sal ammoniac may be introduced into the well in the form of a solution. A common bucket full of saturated solution is sufficient. There is an uncertainty in introducing the sal ammoniac in solution in deep wells, as the time required for the solution to sink to the bottom of the well may be considerable.

The direct-reading ammeter used in the work has two scales, one reading from 0 to 1.5 amperes and the other from 0 to 5 amperes. With a given number of cells, the amount of current between the upstream and a downstream well will depend, of course, upon several factors, such as the depth and distance apart of the wells, but more especially upon the amount of dissolved mineral matter in the ground water. The initial strength of the current can be readily adjusted, however, after the wells have been connected with the instruments, by turning on or off some of the battery cells by means of the switches at the rear of the box. It is a good plan to use enough cells to give an initial current between one-tenth and two-tenths of an ampere.

## RECORDING INSTRUMENTS.

In the second form of underflow meter a self-recording instrument is used in place of the direct-reading ammeter, thus doing away with the tedious work of taking the frequent observations day and night, which are required when direct-reading instruments are used. The arrangement of the apparatus is not materially different from that described above. In the place of the direct-reading ammeter a special recording ammeter is used, of range 0 to 2 amperes. It has been found practicable, although it is a matter of some difficulty, to construct an instrument of this low range that is sufficiently portable for field use and not too delicate for the purpose for which it is intended. The ammeter has a resistance of about 1.6 ohms and is provided with oil dash pot to dampen swing of arm carrying the recording pen. The instruments were manufactured by the Bristol Company. They have gone through hard usage in the field without serious breakage or mishap. The portability of the instruments will be materially increased by changes in design which are now being made.

The method of wiring the wells when the recording instruments are used is slightly changed. In this case one side of the battery circuit is connected to casing of well A and to all of the electrodes of wells B, C, and D. The other side of the battery is run through the recording ammeter to a commutator clock, which once every hour makes a contact and completes the circuit, one after the other, to a series of binding posts. One of these binding posts is connected to the casing of well B, one to the casing of well C, and one to the casing of well D. The period of contact is ten seconds, which gives an abundance of time for the pen to reach its proper position and to properly ink its record.

Pl. V, *B* shows a commutator clock made for this purpose by the instrument maker of the College of Engineering, University of Wisconsin. The clock movement is a standard movement of fair grade, costing less than $5. It can readily be taken from the case for cleaning or oiling and quickly replaced. A good movement with powerful springs is best for this purpose.

It will be seen from the method of wiring the wells that the record will show the sum of the current between well A and well B added to the current between the casing of well B and its electrode. The removal of the connection to well A would permit the record to show the current between the casing of a downstream well and its electrode, but the connection to the upstream well involves no additional trouble and occasionally its indications are of much service, especially if the velocities are low.

One of the instruments above mentioned can be placed in a common box, 16 by 22 by 36 inches, covered with tar paper and locked up. Pl. VI, *B*, is a view of the instruments thus arranged. The shelf contains the recording ammeter (shown at left of cut) and the commutator clock (shown at right of cut).

The contacts on the commutator clock are arranged about five minutes apart, so that the record made for the wells will appear on the chart as a group of lines, one for each downstream well, of length corresponding to the strength of the current. The increasing current corresponding to one of the wells will finally be indicated by the lengthening of the record lines for that well. This can be seen by consulting the records shown in Pl. VII. The record charts are printed in light-green ink and red ink is used in the recording pen, so that record lines can be distinguished when superimposed upon the lines of the chart. A special chart has been designed for this work and is furnished by the Bristol Company as chart 458.

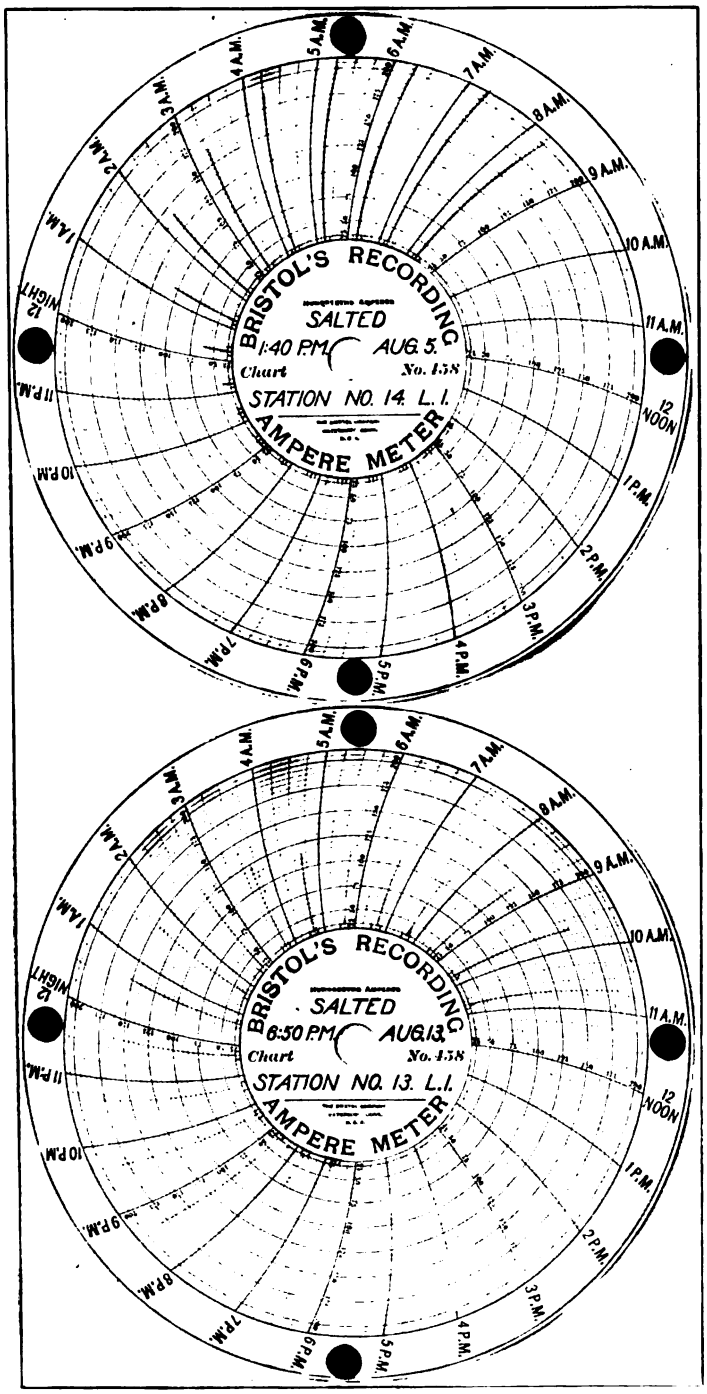
Pl. VII shows two charts made by recording ammeter. In the upper the electrical current for wells B, C, and D, at station 14, Long Island, is recorded, in the order named, at 2.10, 2.15, and 2.20 p. m., and hourly thereafter, the current remaining nearly constant at .22 to .24 ampère until 10.15 p. m., when the current for well C rises as indicated in the chart. In the lower chart the electrical current for wells B, C, and D is recorded, in the order named, at 6.30, 6.35, and 6.40 p. m., and hourly thereafter. The current for wells B and D remains constant at .25 ampere, but the current for well C rises as shown.

The recording instruments in use have given perfect satisfaction and the method is a great improvement in accuracy and convenience over the direct-reading method. The highest as well as the lowest ground-water velocities yet found have been successfully measured

*A.* SIMPLE FORM OF SMALL WELL-JETTING RIG.

The men driving with 150-pound weight stand on platform attached to drivepipe.

*B.* RECORDING AMMETER, COMMUTATOR CLOCK, AND BATTERY BOX IN USE IN THE FIELD, ARRANGED IN A ROUGH BOX, 16 BY 22 BY 36 INCHES IN SIZE.




CHARTS MADE BY RECORDING AMMETER.

by the recording instruments. By using one or two additional dry cells the instrument may be made quite as sensitive as the direct-reading type. In using the recording instruments but a single dose of salt need be placed in the upstream well. If the wells are deep, it is important to use enough salt solution to make sure that the salt reaches as deep as the screen of the well point immediately after the solution is poured into the well. A gallon of solution will fill about 6 feet of full-weight wrought-iron pipe, so that 10 gallons of solution should be used if well is 60 feet deep. If the proper amount of solution be not used, it will take an appreciable time for the solution to reach the bottom of the well by convection currents, and the results

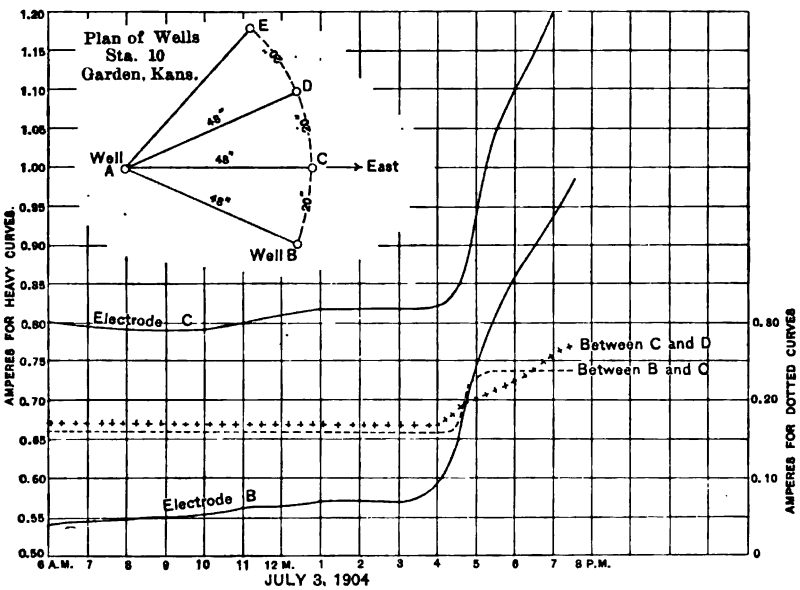



FIG. 6.—Ampere curves at station 10, Garden, Kans. The heavy curves represent the electric current between the casings of wells B and C and the electrodes inside of them. The dotted curves represent the electric current between wells B and C and between C and D. The electric current for the electrode of well B rose earlier than for well C, and the electric current between wells B and C rose earlier and more abruptly than for wells C and D, indicating that the principal stream of electrolyte passed between wells B and C and nearer to well B than to well C.

will be vitiated to that extent. As before stated, it is preferable to introduce into the well granulated sal ammoniac contained in a suitable bucket in case the depth of the well renders the use of a solution uncertain.

In order to properly interpret results obtained in the field with the apparatus, it becomes necessary to investigate the behavior of the dissolved electrolyte as it moves onward with the ground water after leaving the salted well. This matter could be investigated only in the laboratory, and it was sought to reproduce as nearly as possible the conditions found in the field.

Before salting the upstream well of any set of test wells the electric circuit should be closed between each adjacent pair of downstream wells, and the current should be measured with the direct-reading ammeter and recorded in the notebook. An occasional reading of these same circuits will prevent the electrolyte from passing between two of the downstream wells without the knowledge of the observer. This is clearly shown by the results obtained with the set of wells represented in fig. 6. At the location of this station the direction of the flow was at first not correctly estimated on account of its nearness to a river whose height was fluctuating. For that reason the downstream wells were redriven at distances of but 20 inches from one another. The diagram gives the ampère curves for wells B and C, both of which were reached by the electrolyte, and also the curves of current between wells B and C and wells C and D. The actual direction of flow can be seen from these curves to lie between B and C, and probably nearer B than C, since the curve for B rises somewhat earlier and the percentage increase in current is greater. The same fact is shown by the curves representing the current between B and C and between C and D. The main stream of electrolyte must have passed between B and C, as is shown by the more abrupt and earlier use in the current between B and C as compared to that between C and D.

# CHAPTER III.

## LABORATORY EXPERIMENTS ON THE FLOW OF WATER THROUGH SANDS AND GRAVELS.

### OBJECTS OF THE EXPERIMENTS.

During the winters of 1902–3 and 1903–4 experiments were carried on in the laboratory upon the flow of water through sands and gravels contained in tanks. The objects of these experiments were: (1) To verify the law of flow of water through sands and gravels under gradients similar to those found in the field; (2) to ascertain the law of distribution in a horizontal plane of the electrolyte used in the electrical method of determining the rate of flow of underground water; (3) to determine the influence of varying velocities upon this distribution; (4) to determine, if possible, by means of apparatus approximating actual field conditions, the relation between the distribution of the electrolyte and the current curve obtained by the electrical method of measuring ground-water velocities, thereby checking the accuracy of the method and furnishing data indicating more definitely the point on the current curve which should be selected in order to find the velocity of flow.

For the laboratory work of 1902–3 the writer had the assistance of Mr. Henry C. Wolff, and the work of 1903–4 was done by Mr. Ray Owen and H. L. McDonald.

### EXPERIMENTS IN THE HORIZONTAL TANK.

The apparatus used in the first experiments consisted of a horizontal wooden tank of inside dimensions 4 feet 6 inches long, 4 feet wide, and 8 inches deep. A chamber of perforated sheet brass 3 inches wide was inserted in each end of the tank, so that the dimensions of the compartment left for the gravel was 4 by 4 feet in horizontal extent. The area 4 by 4 feet was divided into squares 6 inches on a side, at the corner of each of which a small well of slotted sheet brass, one-half inch in diameter, was fixed in position. A larger well, 2 inches in diameter, of the same material was placed in position as shown in the plan, fig. 7. For the first experiments the tank was filled with about 7 inches of gravel, which we have designated as Picnic Point gravel. The effective size of this gravel, as determined by King's aspirators, was 0.93 mm. Mechanical analysis of the Picnic Point gravels will be found in Table VI.

TABLE VI.—*Mechanical analysis by standard sieves of several gravels referred to in the text.*

| No. of screen-meshes to inch. | Size of separation of screen in millimeters. | Per cent of total weight of sand passing sieve. | | |
|---|---|---|---|---|
| | | Picnic Point gravel. | Madison glacial gravel. | Victorville gravel. |
| 100 | 0.18 | 00.6 | 00.8 | 00.1 |
| 80 | .23 | 1.0 | 1.4 | 0.2 |
| 60 | .32 | 1.6 | 6.3 | 1.3 |
| 40 | .46 | 4.2 | 38.6 | 4.7 |
| 30 | .70 | 14.3 | 83.9 | 13.1 |
| 20 | .93 | 25.6 | 98.1 | 27.8 |
| 16 | 1.30 | 31.4 | 99.6 | 37.2 |
| 14 | 1.40 | 36.8 | 100 | 46.3 |
| 12 | 1.70 | 47.6 | 100 | 63.9 |
| 10 | 2.04 | 54.3 | 100 | 71.0 |
| 8 | 2.48 | 67.5 | 100 | 82.7 |
| Held by 8 | ..... | 32.5 | ..... | 17.3 |

TABLE VII.—*Effect of formalin in preventing clogging of sand filter.*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Duration of experiment. | Average head. | Average flow of water per one-fourth hour. | Flow per unit head. | Temperature. | Mean hydraulic gradient per mile. | Velocity of water per diem. |
| First experiment, Dec. 8: | *Inches.* | *Pounds.* | | °C. | *Feet.* | *Feet.* |
| First 10/4 hours | 0.230 | 6.57 | 28.56 | 14.4 | 25.3 | 15.4 |
| Second 11/4 hours | .227 | 6.48 | 28.54 | ..... | ..... | ..... |
| Second experiment, Dec. 9: | | | | | | |
| First 11/4 hours | .188 | 6.13 | 30.96 | 14.0 | 20.5 | 14.2 |
| Second 11/4 hours | .185 | 6.01 | 30.90 | ..... | ..... | ..... |
| Third experiment, Dec. 11: | | | | | | |
| First 5/4 hours | .170 | 5.75 | 29.22 | 14.0 | 18.9 | 13.7 |
| Second 5/4 hours | .174 | 5.89 | 29.24 | ..... | ..... | ..... |

NOTE.—This table shows the influence of a small amount of formalin in preventing the clogging of a sand filter when water is run through it continuously. Compare the flow per unit head during first portion of each experiment with the flow during the second period, as given in column 4. The experimental error is greater than the small differences in these numbers. The low gradients and the low velocities used can be seen in columns 6 and 7.

The tank of gravel was securely mounted in a horizontal position and gages of glass tubing communicating with the chambers at the

ends of the tank were adjusted to show the level of water at each end of the tank. By means of these gages it was easily possible to measure the height of the water in the end compartments within one two-hundredths of an inch. Water was permitted to flow into one of the end compartments from galvanized tubs placed on a platform scale. From the tubs the water passed through 3 or 4 feet of rubber tubing

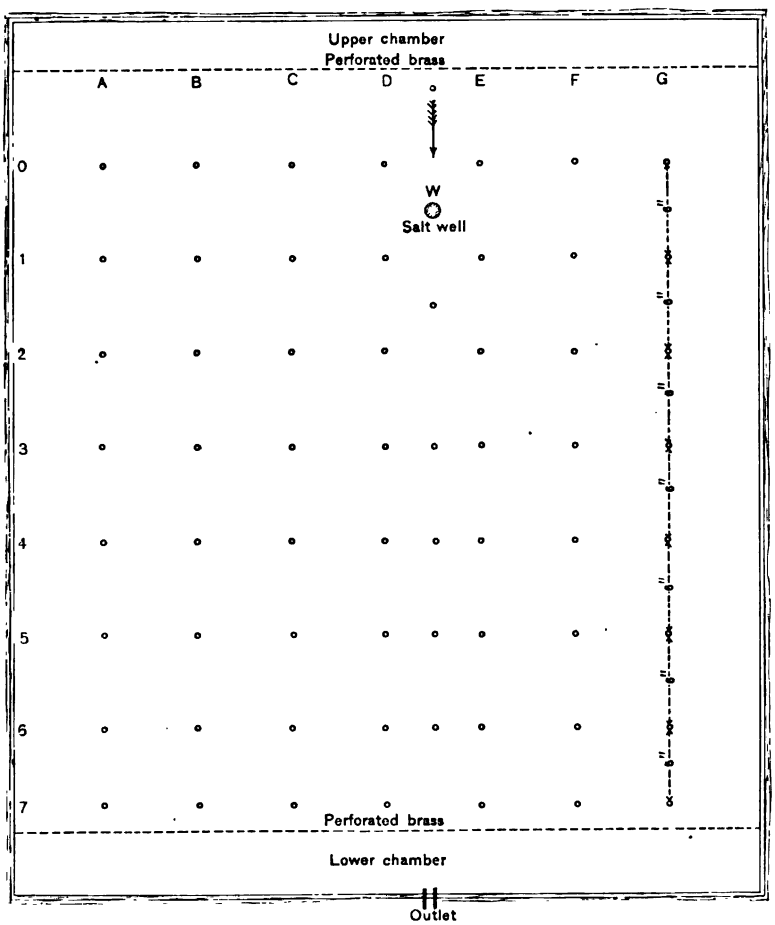



FIG. 7.—Plan of the horizontal tank used in the determination of the spread of an electrolyte when flowing with the water through a sand or gravel. The tank was 4 feet 6 inches long, 4 feet wide, and 8 inches deep. Two perforated brass screens 3 inches from each end left a compartment for gravel 4 by 4 feet in area. A 2-inch well of perforated brass was set at the point marked W, in which the electrolyte was placed. The small circles represent the location of the test wells, from which samples of water could be taken as desired.

to a conically ground needle valve operated by a float placed in the upper compartment or chamber of the tank. It was found possible so to adjust this valve that the level of the water in the upper compartment was maintained constant during an experiment extending over several hours. The water was permitted to escape from the lower

compartment in the tank by means of a ½-inch pipe, the height of the overflow being adjustable.

TABLE VIII.—*Data obtained during experiments on flow of water in horizontal tank.*

| No. | Date of experiment, 1902-3. | Hydraulic gradient. | Average depth of water. | Velocity of ground water. | Velocity per unit head. | Temperature of water. | Salt used in experiment. |
|---|---|---|---|---|---|---|---|
| | | *Ft. per mile.* | *Inches.* | *Ft. in 24 hrs.* | *Ft. in 24 hrs.* | °*C.* | |
| 1.... | Dec. 8 | 25.30 | 5.84 | 15.4 | 0.61 | 14.4 | None used. |
| 2.... | Dec. 9 | 20.50 | 5.83 | 14.2 | .69 | 14.0 | Do. |
| 3.... | Dec. 11 | 18.90 | 5.82 | 13.7 | .63 | 14.0 | Do. |
| 4.... | Dec. 20 | 18.70 | 5.88 | 13.2 | .70 | 20.5 | Dry $NH_4Cl$. |
| 5.... | Jan. 3 | 17.60 | 5.12 | 12.9 | .73 | 20.0 | Do. |
| 6.... | Jan. 7 | 21.45 | 5.10 | 12.1 | .56 | 18.8 | Dry NaCl. |
| 7.... | Jan. 14 | 22.00 | 5.12 | 13.8 | .63 | 17.8 | Con. $NH_4OH$. |
| 8.... | Jan. 17 | 18.54 | 5.09 | 9.3 | .50 | 18.8 | Do. |
| 9.... | Jan. 30 | 18.92 | 5.18 | 11.6 | .61 | 17.8 | Dry $\frac{9}{10}$ $H_4Cl$. $\frac{1}{10}$ NaOH. |
| 10.... | Feb. 9 | 19.03 | 5.17 | 11.25 | .59 | 20.0 | Dry $\frac{8}{10}$ $NH_4Cl$. $\frac{2}{10}$ NaOH. |
| 11.... | Feb. 18 | 21.45 | 5.15 | 11.68 | .54 | 18.8 | Sol. $NH_4Cl$. |
| 12.... | Feb. 23 | 42.35 | 5.28 | 21.70 | .51 | 19.1 | Do. |
| 13.... | Mar. 3 | 64.90 | 5.21 | 36.00 | .55 | 20.1 | Do. |
| 14.... | Mar. 9 | 64.24 | 5.21 | 35.5 | .55 | 20.3 | Sol. $\frac{9}{10}$ $NH_4Cl$. $\frac{1}{10}$ NaOH. |
| 15.... | Mar. 16 | 66.55 | 5.25 | 36.4 | .55 | 21.7 | Dry $\frac{9}{10}$ $NH_4Cl$. $\frac{1}{10}$ NaOH. |
| 16.... | May 4 | 103.2 | 6.68 | 11.47 | .11 | 22.0 | $NH_4Cl$. |
| 17.... | May 14 | 105.6 | 6.70 | 11.60 | .11 | 18.2 | $\frac{9}{10}$ $NH_4Cl$. $\frac{1}{10}$ NaOH. |
| 18.... | May 23 | 107.8 | 6.69 | 11.90 | .11 | ..... | NaOH. |

NOTE.—In experiments 1–15 "Picnic Point gravel" was used, and in experiments 16, 17, 18 Madison glacial sand was used.

The water used in the experiment was obtained from Lake Mendota, Madison, Wis., and before use was freed from suspended material by passing through a filter of charcoal and sand. Before passing through the gravel in the tank, one part in 500 of 40 per cent solution of formalin was added to the water so as to inhibit the growth of organisms. Previous experimenters on the flow of water through sands and gravels experienced much difficulty on account of the progressive reduction in flow of water through the sand when an experiment extended over a considerable length of time. No means had been found for avoiding this difficulty; even the use of distilled water was not entirely effective. It was difficult to explain this phenomenon except on the basis of the growth of organisms in the pores of the

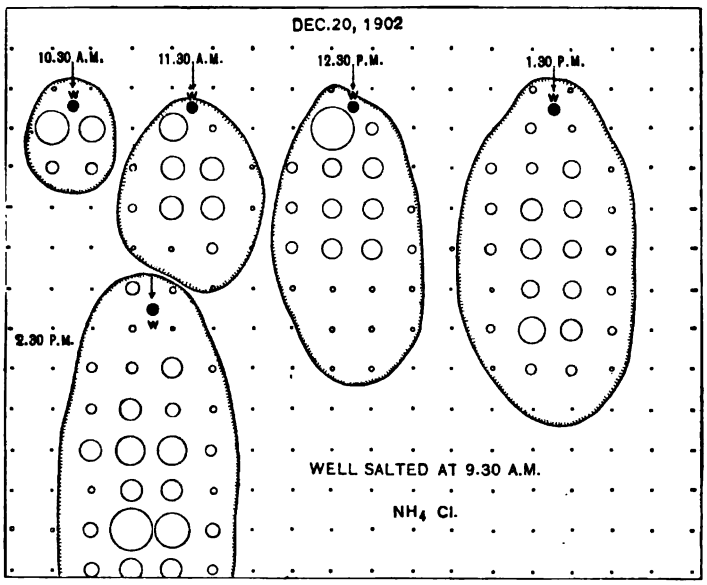



FIG. 8.—Diagram showing the manner in which the electrolyte spread in passing downstream with the ground water, in experiment 4, in the horizontal tank. The dot at W shows the location of the salted well, and samples were taken from the sand from the small test wells represented by dots in the diagram. The areas of the circles are proportional to the strength of the electrolyte found at their centers. The area covered by the charged water at the time specified is shown by a roughly sketched outline. The velocity of the ground water in the direction of the arrows was 13.2 feet for twenty-four hours. Electrolyte used was sal ammoniac.

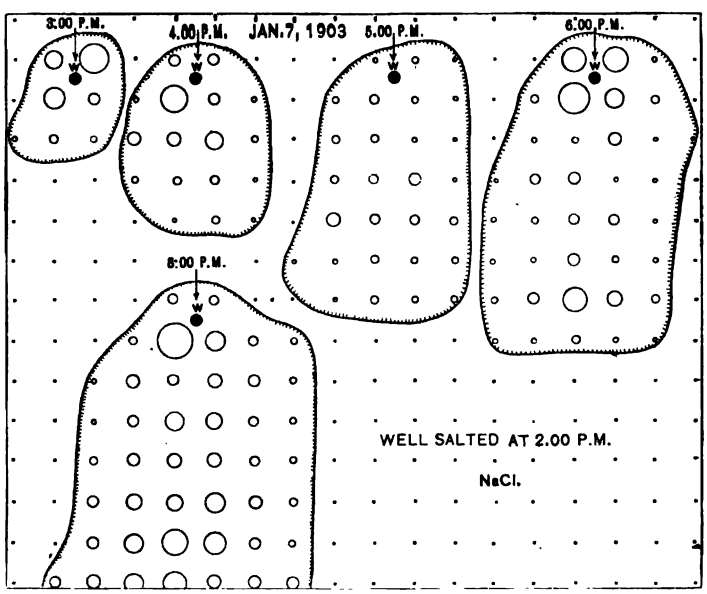



FIG. 9.—Diagram showing the results of experiment 6. Representation of wells and other features as in fig. 8. The velocity of the ground water was 12.1 feet for twenty-four hours. The electrolyte used was common salt.

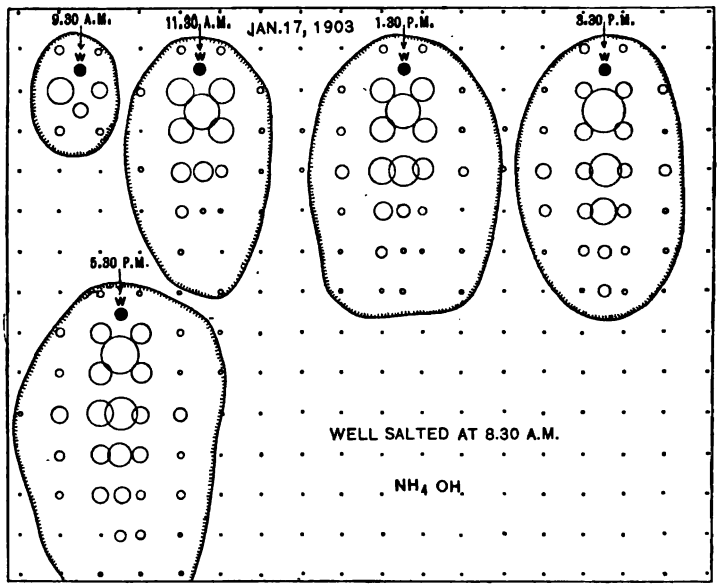



FIG. 10.—Diagram showing the results of experiment 8. Representation of wells and other features as in fig. 8. The velocity of the ground water was 9.3 feet for twenty-four hours. The electrolyte used was concentrated ammonia water.

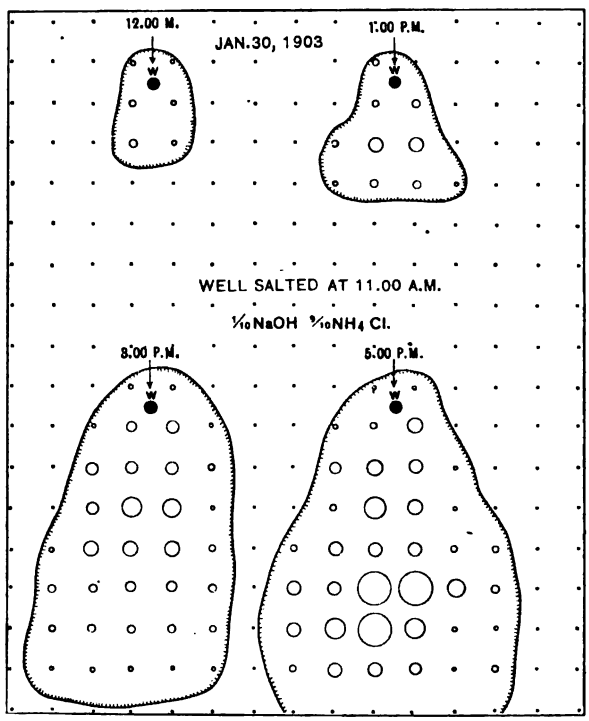



FIG. 11.—Diagram showing the results of experiment 9. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.6 feet for twenty-four hours. The electrolyte used was one-tenth caustic soda and nine-tenths sal ammoniac.

sand used in the experiments. For this reason the formalin was added to the water in the hope that if this were the correct explanation the difficulty would vanish. Several experiments were made for the especial purpose of determining the effect of the formalin in inhibiting the organic growth in the filter. Table VII gives the result of three such experiments. The duration of each experiment was divided into two nearly equal periods, and the average head of water as shown by the gages and the average flow of water, as determined by weighing both the water admitted to the tank and the water leaving it at the

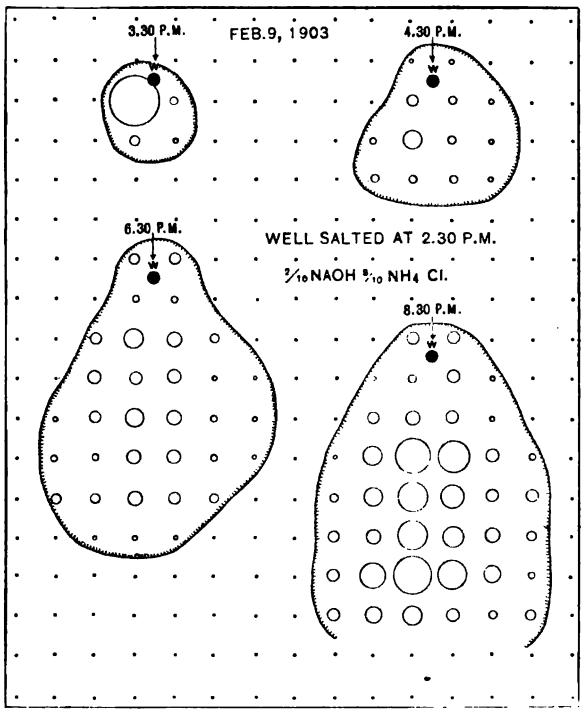



FIG. 12.—Diagram showing the results of experiment 10. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11¼ feet for twenty-four hours. The electrolyte was two-tenths caustic soda and eight-tenths sal ammoniac.

lower end, were determined for each of the two periods into which each experiment was divided. It will be seen by consulting column 4 of the table that the flow of water per unit head during the first portion of each experiment was essentially identical per unit head to the second portion of each experiment. The slight differences in the numbers is much smaller than the unavoidable experimental error. It was concluded, therefore, that the progressive clogging of a sand filter is due to the growth of organisms, and that the formalin added constituted an effective remedy.

Altogether 18 experiments were carried out in this tank. In the first 15 tests Picnic Point gravel was used in the tank; during the last 3 fine glacial sand replaced the Picnic Point gravel. The glacial sand had effective size of grain, as determined by King's aspirator, of 0.40 mm. A mechanical analysis of the sand is given in Table VI,

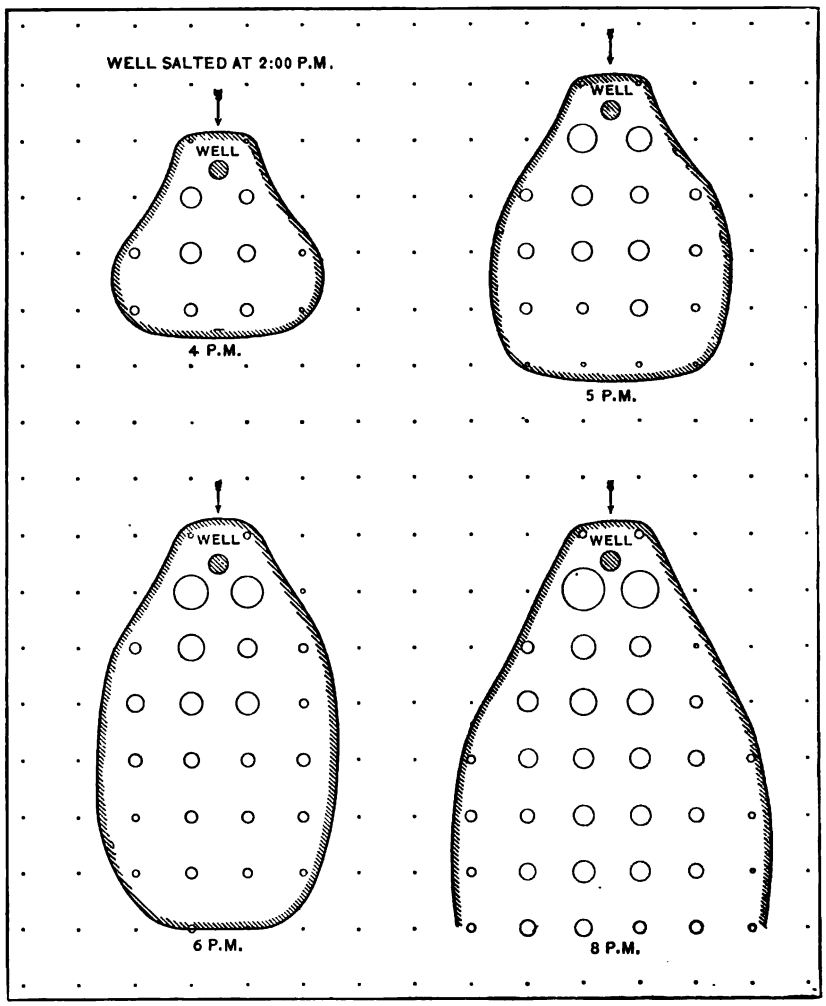



FIG. 13.—Diagram showing the results of experiment 11. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.7 feet for twenty-four hours. The electrolyte was sal ammoniac in concentrated solution.

(p. 30), and a summary of the data obtained during the experiments is placed in Table VIII.

No difficulty was experienced in maintaining very low gradients to the water plane in the tank, a slope of water of 18 feet to the mile being easily brought about by proper adjustment in the apparatus. In this way actual field conditions of the flow of water were very

closely approximated, and velocities less than 10 feet a day could be maintained by the use of the low gradients. The large well marked W was designed to receive various electrolytes while the water was moving through the gravel under the selected uniform head. The small one-half inch wells placed at the corners of the 6 inch squares were designed to serve as test wells from which samples of the water could be taken at stated intervals, and the exact area spread over by the electrolyte could be ascertained by chemical analyses. A series of pipettes were coupled together in such a way as to permit the taking of a sample from each row of test wells at the same time. By the use

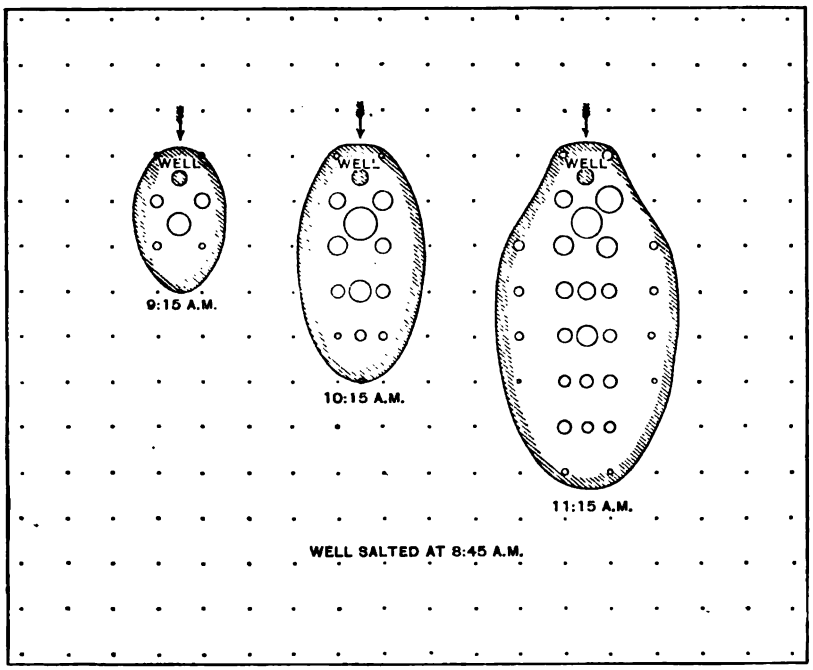



FIG. 14.—Diagram showing the results of experiment 12. Representation of wells and other features as in fig. 8. The velocity of the ground water was 21.7 feet for twenty-four hours. The electrolyte was sal ammoniac in concentrated solution.

of this device a complete set of samples could be taken from all the test wells in the tank in a very few minutes.

The results of the experiments are best shown by the series of diagrams figs. 8 to 20, in which the strength of the electrolyte found at each test well is shown by a circle of appropriate size.

Among the various electrolytes tested were ammonium chloride (sal ammoniac), sodium chloride (common salt), concentrated ammonia water, and mixtures of ammonium chloride and caustic soda, or lye. One of the most remarkable conclusions from the experiments was that diffusion plays but a very small part in the spread of the electrolyte through the ground water. In none of the experiments was it found

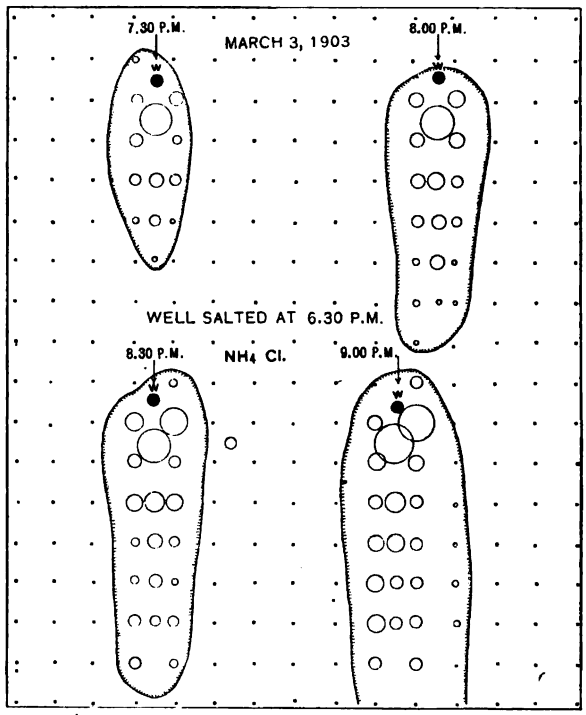



FIG. 15.—Diagram showing the results of experiment 13. Representation of wells and other features as in fig. 8. The velocity of the ground water was 36 feet for twenty-four hours. The electrolyte was sal ammoniac in concentrated solution. Note the narrow stream of electrolyte due to the high velocity.

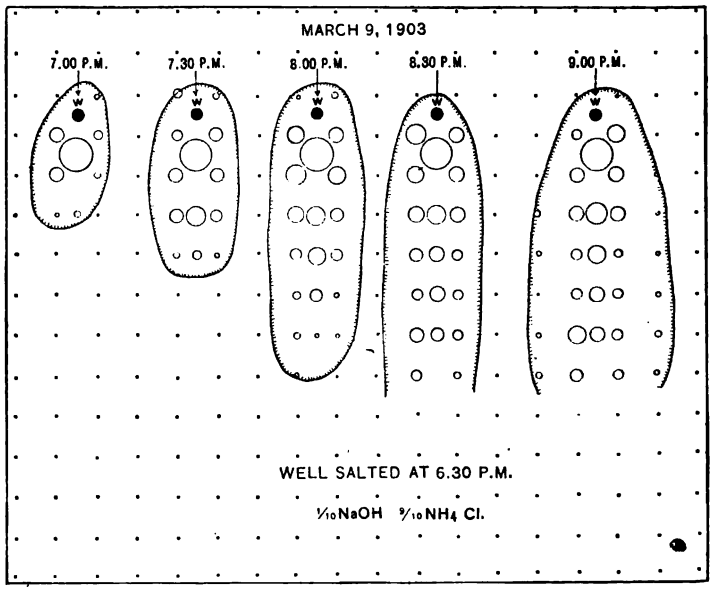



FIG. 16.—Diagram showing the results of experiment 14. Representation of wells and other features as in fig. 8. The velocity of the ground water was 35½ feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac in solution.

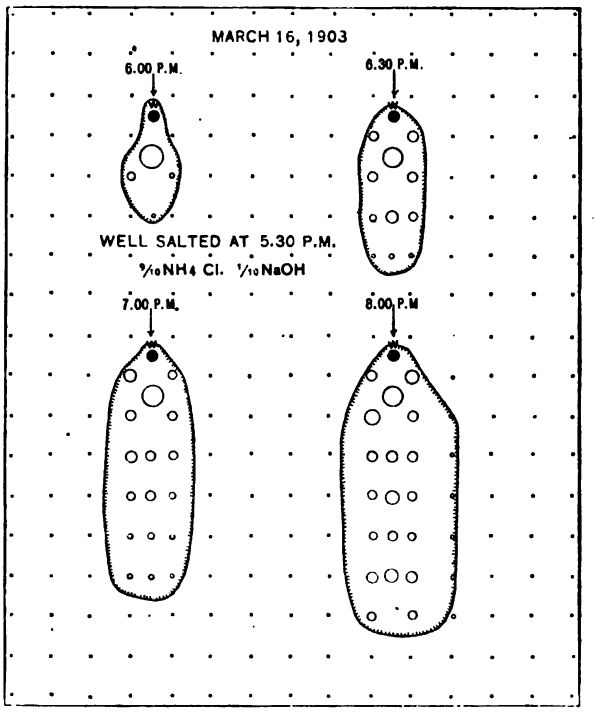



FIG. 17.—Diagram showing the results of experiment 15. Representation of wells and other features as in fig. 8. The velocity of the ground water was 36.4 feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac in dry crystals.

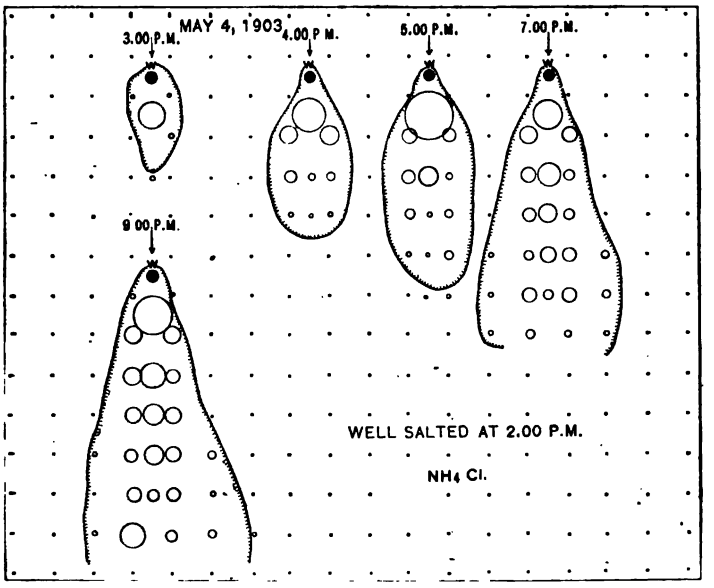



FIG. 18.—Diagram showing the results of experiment 16. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.5 feet for twenty-four hours. The electrolyte was sal ammoniac.

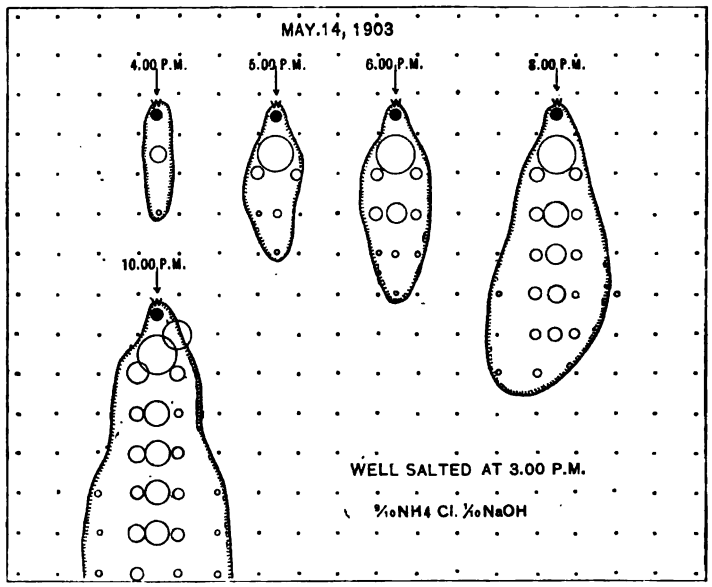



FIG. 19.—Diagram showing the results of experiment 17. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.6 feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac.

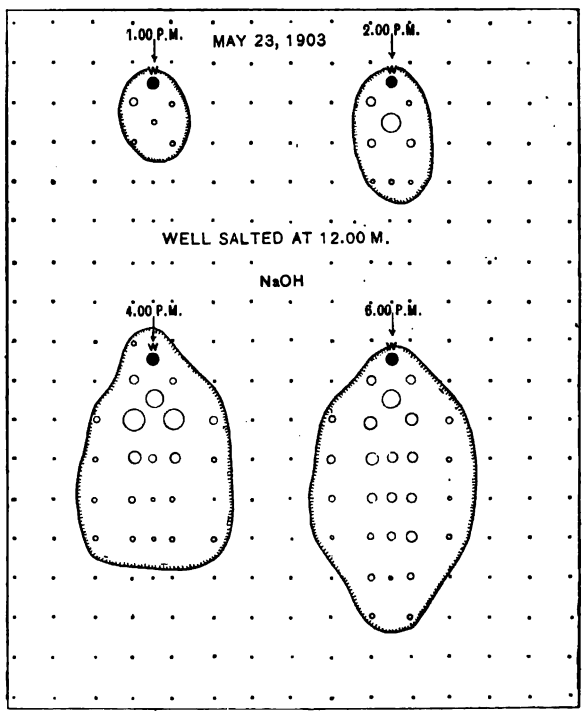



FIG. 20.—Diagram showing the results of experiment 18. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.9 feet for twenty-four hours. The electrolyte was caustic soda.

that the electrolyte extended more than about 3 inches upstream from the large well W. This fact can be seen by consulting the series of diagrams illustrating the distribution of electrolyte. In general, it that the electrolyte moves downstream in a pear-shaped width of the stream varying somewhat with the nature olyte used. The high velocities always gave a stream which was quite narrow and the low velocities gave ms. The solution of concentrated ammonia water gave stream. This was probably due not so much to the difne ammonia gas in the water as to the low coefficient of f the ammonia water. Experiments in the field had indithe mixture of sal ammoniac and caustic soda would spread der stream than sal ammoniac alone. By comparing the experiments 14 and 15 with that of experiment 13, it will at this assumption could not be verified to any considerable extent. In a similar way, experiments 9 and 10 may be compared with experiment 8, and experiments 17 and 18 may be compared with experiment 16.

lusively shown by these experiments, as has been 2–23), that the diffusion of the dissolved salt plays the way in which the electrolyte is distributed in of ground water, but, as already stated, that the ter in each capillary pore of the soil moves faster ntact with the walls of the capillary pore. Likehe electrolyte, as shown by these experiments, is y the diffusion of the salt, but must be explained anching and subdivision of the capillary pores l grains of the sand. The stream of electrolyte well W will gradually broaden as it passes downthread of it must divide and divide again and h each succeeding grain of soil. If diffusion had rate of spread, it would also make itself apparent am motion to the electrolyte against the current s before stated, in no case did the electrolyte stream a distance as great as 3 inches.

## EXPERIMENTS IN THE VERTICAL TANK.

The experiments carried on in the winter of 1903–4 had as their object, in addition to those of the previous year, the determination of the law of distribution of the electrolyte in a vertical plane. For this purpose a tank was constructed of wood, as shown in fig. 21 and Pl. VIII. The inside dimensions of this tank were 4 feet high, 4 feet 6 inches long, and 8 inches wide. At each end of the tank chambers 3 inches wide were constructed of perforated brass, similar to those

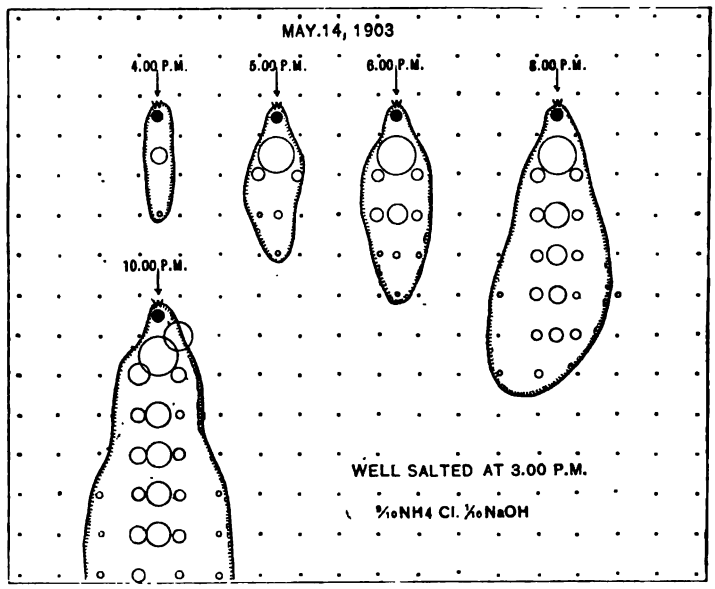



FIG. 19.—Diagram showing the results of experiment 17. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.6 feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac.

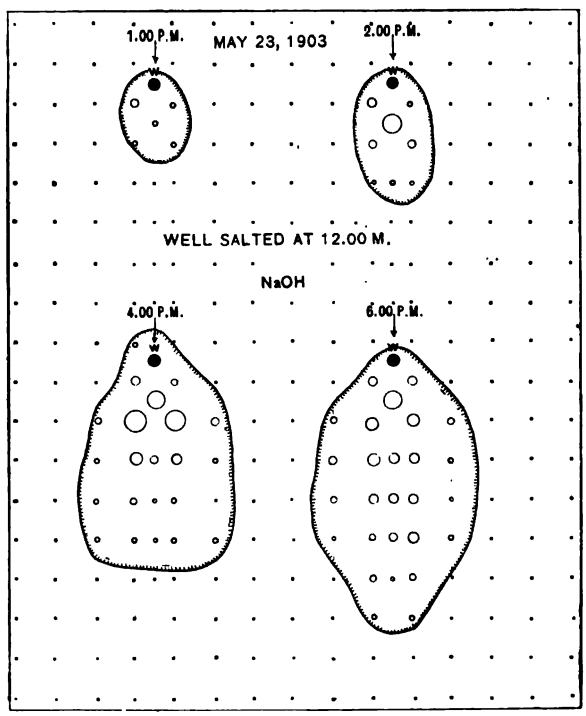



FIG. 20.—Diagram showing the results of experiment 18. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.9 feet for twenty-four hours. The electrolyte was caustic soda.

that the electrolyte extended more than about 3 inches upstream from the large well W. This fact can be seen by consulting the series of diagrams illustrating the distribution of electrolyte. In general, it can be seen that the electrolyte moves downstream in a pear-shaped mass, the width of the stream varying somewhat with the nature of the electrolyte used. The high velocities always gave a stream of electrolyte which was quite narrow and the low velocities gave broader streams. The solution of concentrated ammonia water gave the broadest stream. This was probably due not so much to the diffusion of the ammonia gas in the water as to the low coefficient of viscosity of the ammonia water. Experiments in the field had indicated that the mixture of sal ammoniac and caustic soda would spread in a broader stream than sal ammoniac alone. By comparing the results of experiments 14 and 15 with that of experiment 13, it will be seen that this assumption could not be verified to any considerable extent. In a similar way, experiments 9 and 10 may be compared with experiment 8, and experiments 17 and 18 may be compared with experiment 16.

It seems to be conclusively shown by these experiments, as has been already stated (pp. 22–23), that the diffusion of the dissolved salt plays a very small part in the way in which the electrolyte is distributed in the moving current of ground water, but, as already stated, that the central thread of water in each capillary pore of the soil moves faster than the water in contact with the walls of the capillary pore. Likewise the spread of the electrolyte, as shown by these experiments, is not to be explained by the diffusion of the salt, but must be explained by the continued branching and subdivision of the capillary pores around the individual grains of the sand. The stream of electrolyte issuing from the salt well W will gradually broaden as it passes downstream, because each thread of it must divide and divide again and again as it meets with each succeeding grain of soil. If diffusion had much to do with its rate of spread, it would also make itself apparent by causing an upstream motion to the electrolyte against the current of ground water. As before stated, in no case did the electrolyte succeed in moving upstream a distance as great as 3 inches.

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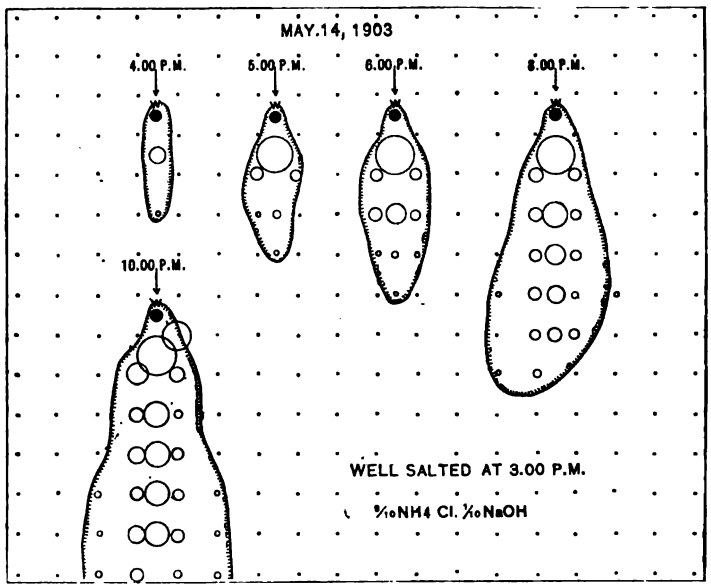


FIG. 19.—Diagram showing the results of experiment 17. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.6 feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac.

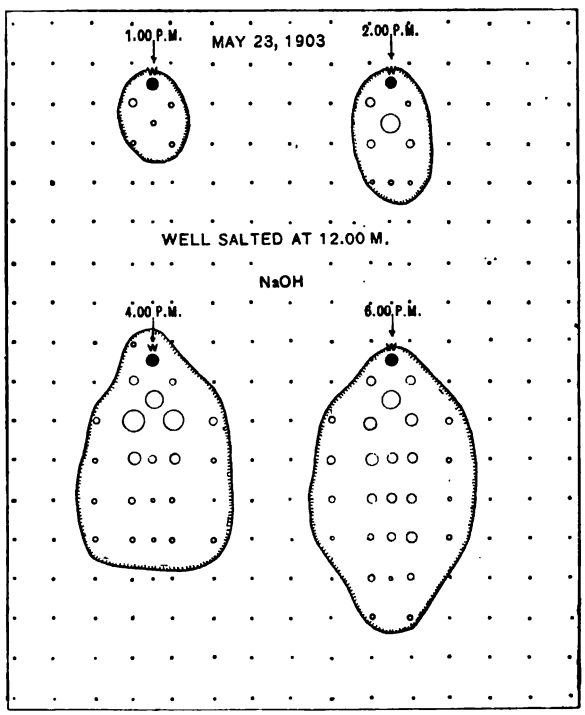


FIG. 20.—Diagram showing the results of experiment 18. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.9 feet for twenty-four hours. The electrolyte was caustic soda.

that the electrolyte extended more than about 3 inches upstream from the large well W. This fact can be seen by consulting the series of diagrams illustrating the distribution of electrolyte. In general, it can be seen that the electrolyte moves downstream in a pear-shaped mass, the width of the stream varying somewhat with the nature of the electrolyte used. The high velocities always gave a stream of electrolyte which was quite narrow and the low velocities gave broader streams. The solution of concentrated ammonia water gave the broadest stream. This was probably due not so much to the diffusion of the ammonia gas in the water as to the low coefficient of viscosity of the ammonia water. Experiments in the field had indicated that the mixture of sal ammoniac and caustic soda would spread in a broader stream than sal ammoniac alone. By comparing the results of experiments 14 and 15 with that of experiment 13, it will be seen that this assumption could not be verified to any considerable extent. In a similar way, experiments 9 and 10 may be compared with experiment 8, and experiments 17 and 18 may be compared with experiment 16.

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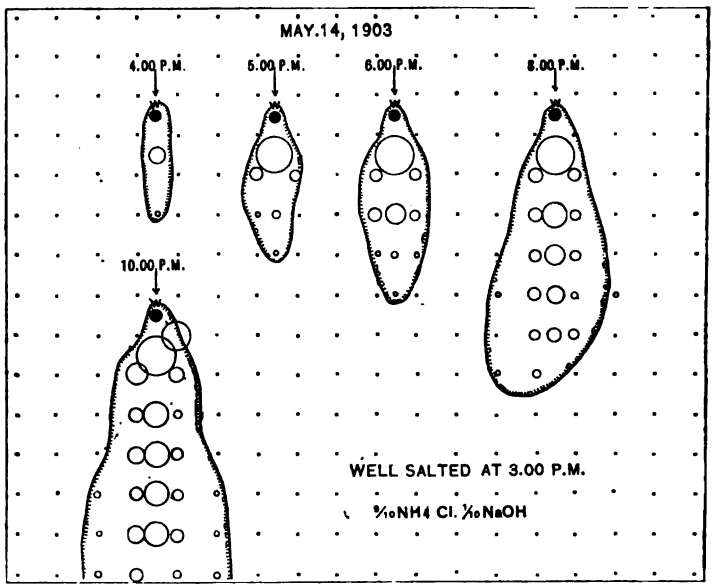


FIG. 19.—Diagram showing the results of experiment 17. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.6 feet for twenty-four hours. The electrolyte was one-tenth caustic soda and nine-tenths sal ammoniac.

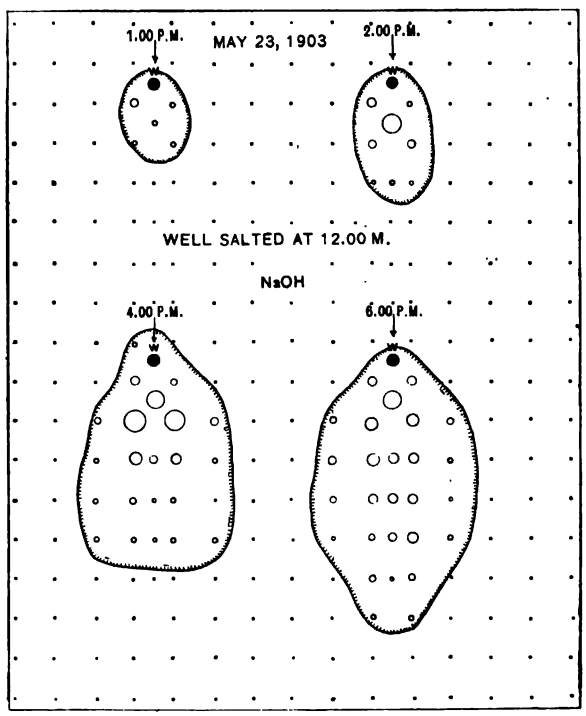


FIG. 20.—Diagram showing the results of experiment 18. Representation of wells and other features as in fig. 8. The velocity of the ground water was 11.9 feet for twenty-four hours. The electrolyte was caustic soda.

that the electrolyte extended more than about 3 inches upstream from the large well W. This fact can be seen by consulting the series of diagrams illustrating the distribution of electrolyte. In general, it can be seen that the electrolyte moves downstream in a pear-shaped mass, the width of the stream varying somewhat with the nature of the electrolyte used. The high velocities always gave a stream of electrolyte which was quite narrow and the low velocities gave broader streams. The solution of concentrated ammonia water gave the broadest stream. This was probably due not so much to the diffusion of the ammonia gas in the water as to the low coefficient of viscosity of the ammonia water. Experiments in the field had indicated that the mixture of sal ammoniac and caustic soda would spread in a broader stream than sal ammoniac alone. By comparing the results of experiments 14 and 15 with that of experiment 13, it will be seen that this assumption could not be verified to any considerable extent. In a similar way, experiments 9 and 10 may be compared with experiment 8, and experiments 17 and 18 may be compared with experiment 16.

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period after the beginning of the experiment. A single dose of 2 ounces of sal ammoniac was introduced into the well W at 11.40 a. m.,

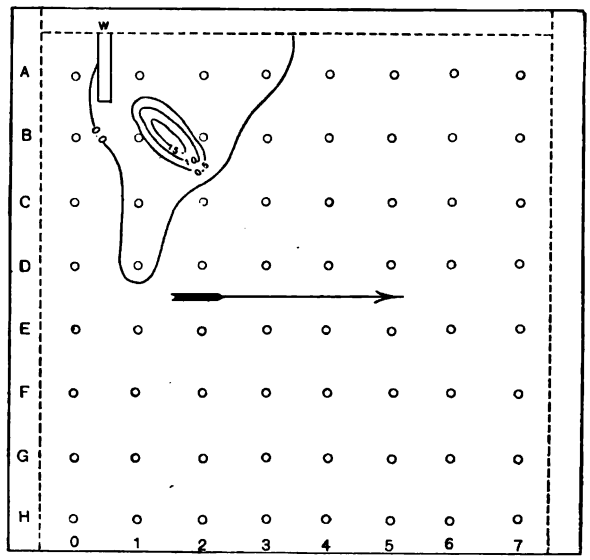



FIG. 23.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1¼ inches. The contours show the distribution of salt at 12.40 p. m.

on February 22, 1904. As will be observed by consulting the diagrams, the dissolved salt entered the ground water and passed to the

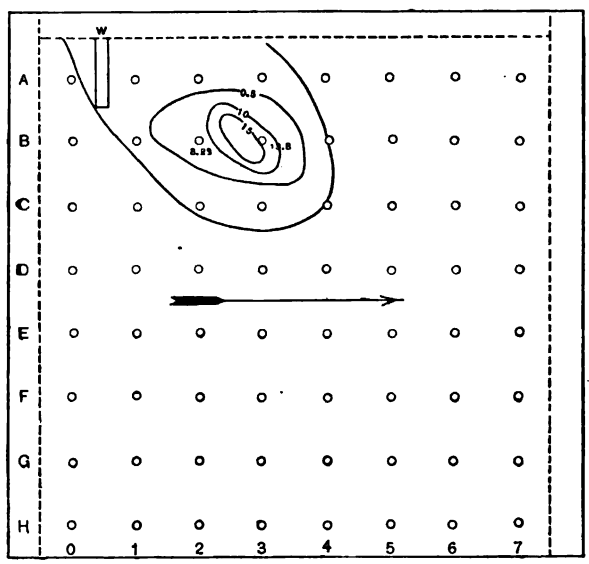



FIG. 24.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac, velocity of the ground water was 17.06 feet a day; head, 1¼ inches. The contours show the distribution of salt at 1.40 p. m

right with the moving stream, at the same time moving slightly downward, as shown by the contour curves. The velocity of water through

the gravel during this experiment was about 17 feet for twenty-four hours. The elliptical outline of the contour curves is due to the two

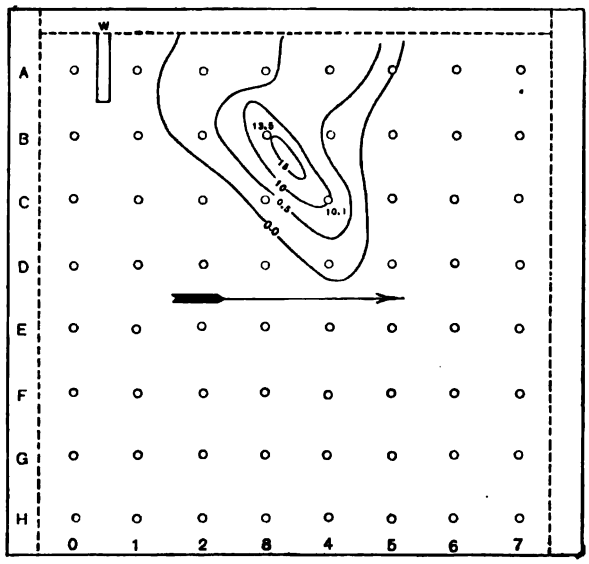



FIG. 25.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1½ inches. The contours show the distribution of salt at 2.40 p. m.

components of motion, one component being the velocity of ground water to the right, and the other being the downward motion, due to

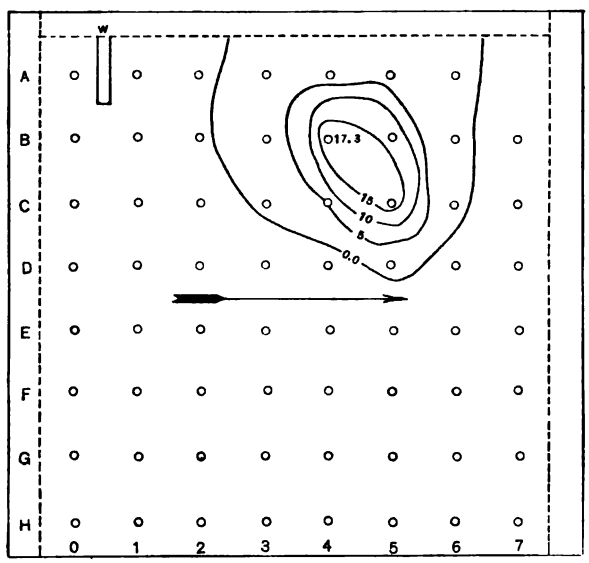



FIG. 26.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1½ inches. The contours show the distribution of salt at 3.40 p. m.

the high density of the solution of sal ammoniac. It will be noticed that the elliptical contour lines have their longest dimension sloping

downward to the right, as they should if they represent the resultant of these two motions. It should also be noted (consult the diagrams)

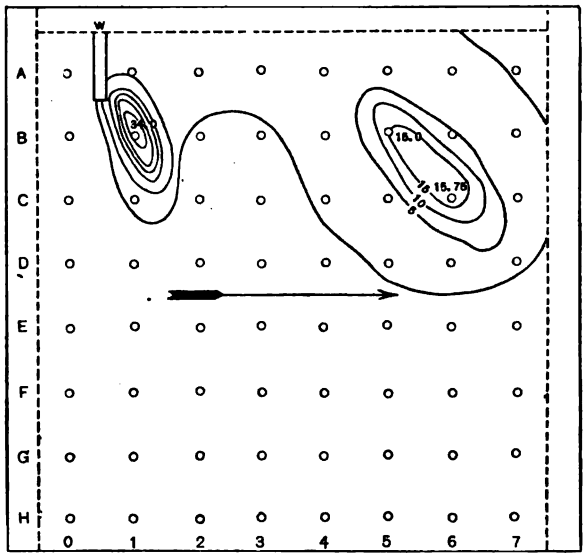



FIG. 27.—Diagram showing results of vertical-tank experiment 1, February 22, 1904. Well W was salted at 11.40 a. m. with sal ammoniac; velocity of the ground water was 17.06 feet a day; head, 1½ inches. The contours show the distribution of the salt at 4.40 p. m. A second dose of salt was placed in well W at 4 p. m., and the diagram represents the two masses of electrolyte passing forward with the ground water.

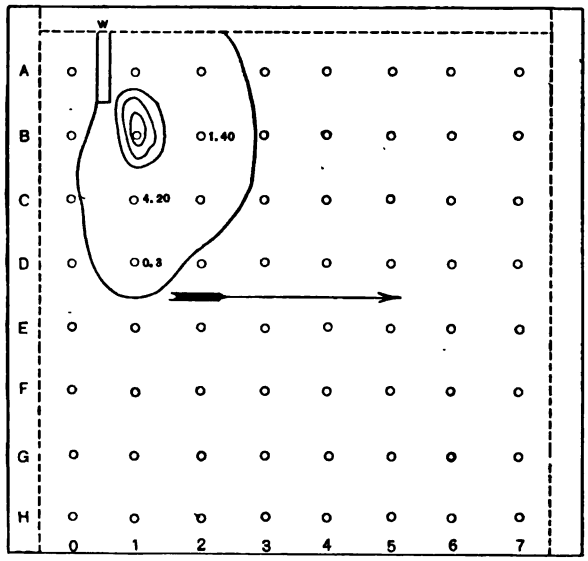



FIG. 28.—Diagram showing results of vertical-tank experiment 2, March 2, 1904. Well W was salted at 2.25 p. m. The velocity of ground water was 11.42 feet a day; head, 1 inch. The salt used was sal ammoniac. Contours show the distribution of salt at 2.55 p. m.

that after an interval of an hour nearly all of the electrolyte had left well W, and the water in the well had become fresh again. At 4 p. m.

an additional dose of sal ammoniac was placed in well W, the effect of which is clearly shown in the contour curves for 4.40 p. m. Here two masses of dissolved electrolytes can be observed traveling simultaneously through the sand. It should also be noted in these diagrams that the electrolyte does not pass upstream, or against the current of ground water more than 1 or 2 inches.

Two sets of contour curves are also given for the second experiment, that of March 2, 1904, in which the same electrolyte was used, but the velocity of the ground water was reduced to 11.42 feet for twenty-four hours. The well W was salted at 2.25 p. m., contours being given for 2.25 and 7.25 p. m. It will be observed that for the lower velocity of ground water the electrolyte sinks to a greater depth than in the case

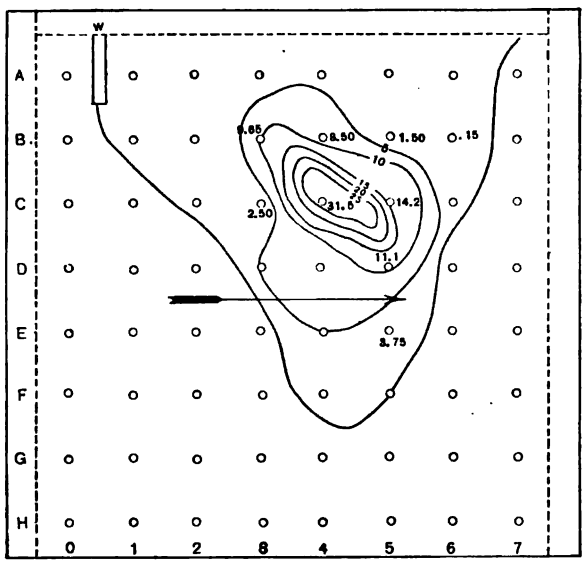



FIG. 29.—Diagram showing results of vertical-tank experiment 2, March 2, 1904. Well W was salted at 2.25 p. m. The velocity of ground water was 11.42 feet a day; head, 1 inch. The salt used was sal ammoniac. The contours show the distribution of salt at 7.25 p. m. A comparison of figs. 28 and 29 with 22 to 27 shows the larger vertical motion of the electrolyte, in the case of the lower velocity of experiment 2, as compared with the higher velocity prevailing during experiment 1.

of the higher velocities of the first experiment. Experiments were also carried out with common lye as electrolyte. This salt is very much heavier than sal ammoniac, and it was noted that it sank much faster than the solution of sal ammoniac for similar velocities of ground water.

One of the most interesting experiments with the vertical tank was made for the purpose of determining the amount of diffusion of the electrolyte. For this purpose the electrolyte was introduced into the well W and the ground water was permitted to remain stationary, no water being run into or out of the tank during the eight hours covered by the experiment. The well W is placed exactly midway between

columns 0 and 1 of the small test wells, as can be seen from the diagram. For the purpose of the "still" experiment the uppermost test well of column 2 was removed and well W was placed directly over column 2. A charge of salt was introduced into the well W at 9 a. m., and samples were taken at the end of one-half hour and at the end of each hour thereafter until 5 p. m. The salt was found to drop vertically with a rapidity equal to the vertical component of motion noted in the experiments in which flow took place. In the eight hours of the test no portion of the charge could be detected in the test wells of columns 1 or 3. This experiment showed that the electrolyte had not

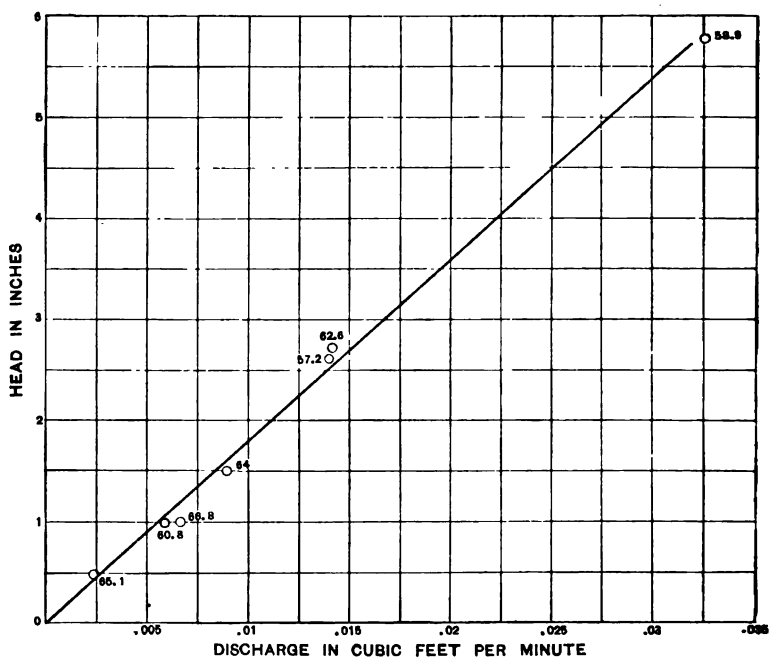



FIG. 30.—Diagram illustrating the variation in the rate of flow of ground water with the variation in head or hydraulic gradient, as observed in the experiments in the vertical tank. The figures attached to the small circles in the diagram designate the temperature, Fahrenheit, of the ground water during the experiment. The straight line represents the theoretical law of flow if the rate of flow varies directly as the head.

diffused sufficiently to reach the wells of columns 1 and 3, while dropping a vertical distance of about 3 feet.

The law of direct variation of the flow of ground waters with the head under which the flow takes place are verified by the experiments in the tank. The results are represented graphically in fig. 30. Exact agreement with this law would require all of the plotted points in this diagram to lie upon the straight line, provided the temperatures were the same. The larger departures from the straight line are not due to temperature differences, but to the high viscosity of the lye solutions used in those particular experiments.

## INVESTIGATION OF THE ACCURACY OF THE ELECTRIC METHOD OF DETERMINING THE VELOCITY OF THE FLOW OF GROUND WATERS.

The vertical tank offered a ready means of checking the accuracy of the method of measuring the velocity of ground waters with the electric underflow meter. For this purpose the chambers of perforated brass at the upper and lower ends of the tank served as the upstream and downstream wells, respectively, and an electrode was sunk in the sand 2 inches from the lower partition, which answered the purpose of the electrode usually placed inside the downstream well. The apparatus was then connected in accordance with the method used in actual field work. A solution of sal ammoniac was placed in the upper chamber. The water running through the tank was weighed before it entered and after it left the apparatus, and observations were made of the electric current every fifteen minutes and sometimes oftener. Two experiments were made, one with a head of water of 2.68 inches and one with a head of 5.75 inches. From the weight of water discharged the computed velocity during the former was 23.15 feet a day, and during the latter the velocity was 58 feet a day. From the points of inflection of the two electrode curves the velocities were computed to be, respectively, 23.25 and 64.10 feet a day. This shows agreement in the case of the lower velocity within a very small fraction of 1 per cent, and in the case of the higher velocity within 10½ per cent of the actual rates. These results show that the electric method is sufficiently accurate for the purposes for which it is intended. It is very likely that if the tank in which these experiments were carried out had been wider the percentage agreement for the high velocity would be even closer than 10 per cent, for it must be remembered that the narrowness of the tank tended to bring the concentrated portion of the stream of electrolyte to a given downstream point more rapidly than if the tank had been wide enough to permit the electrolyte to spread in its natural way.

## CHAPTER IV.

### MEASUREMENTS OF THE UNDERFLOW AT THE NARROWS OF THE RIO HONDO AND SAN GABRIEL RIVER, CALIFORNIA.

The following underflow measurements were made during the summer of 1902 at the narrows of the Rio Hondo and the San Gabriel River, about 10 miles east of Los Angeles, Cal. The ultimate source of the streams referred to is found in the San Gabriel Mountains, a range which runs nearly east and west about 40 or 50 miles from the southern coast line of California. The main portion of the mountain drainage which supplies this particular stream is collected into one of the large canyons of the range, known as the San Gabriel Canyon. Like that of other streams that originate in these mountains, the water is not carried above ground much farther than the mouth of the canyon, except in times of extreme flood. The ordinary flow of the river sinks into an enormous alluvial delta cone of gravel and mountain débris, and passes underground in a broad, gently sloping valley until it is interrupted by a line of shale hills about 10 miles south of the mountain range. This line of hills acts as a dam to the underground waters, except for a break about 2 miles in width, where the drainage of the valley escapes to the sea. This break constitutes the so-called "Narrows" of the river. In consequence of the narrow outlet a large quantity of the ground water is brought to the surface, first showing itself about 2 miles above the narrows, and increasing in volume as it enters the contracted part of the pass. At the present time the surface waters appear as two distinct streams, the Rio Hondo on the west side and the San Gabriel River on the east side of the narrows.

In August, 1900, the flow of the Hondo at Old Mission bridge was 23 second-feet. The flow of the San Gabriel was somewhat larger. The Whitney electrolytic bridge indicates that the ground water and surface waters are substantially identical in character, containing 15 to 25 parts per 100,000 total solids.

The measurements of the rate of underflow were made by the electrical method as previously described in this paper. At the time of making these measurements the recording instruments had not been perfected for field use, so that all of the work was done with the hand apparatus. The test wells used were 2-inch drive wells, with 42-inch

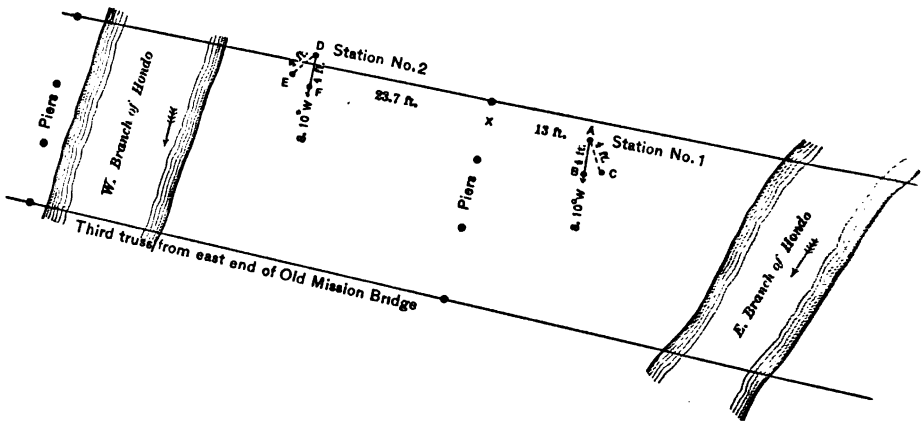
points and 48-inch well-point extensions. The wells were arranged as usual, one upstream, designed to receive the electrolyte, and the others downstream, 2 feet apart on an arc of a circle of 4-foot radius. In most instances the electrolyte moving with the ground water would show itself at but one of the downstream wells, but in one or two cases it reached two of the downstream wells, and in a few cases the first setting of the wells did not correspond to the actual direction of the motion, so that the lower wells were not touched at all by the dissolved electrolyte.

Measurements were made at four stations located within the narrows of the rivers named. The first and second stations were located under a wagon bridge over Rio Hondo near the Old Mission. Two groups of wells were driven, and the location and direction of these wells with reference to the bridge are shown in fig. 31. The electrical current was observed separately for a circuit between the casing of the upstream well and the casing of each of the downstream wells, and also for the circuit between the casing of each downstream well and the brass rod electrode contained within it, a direct-reading ammeter being used. The velocity at the first station was 3.8 feet per diem. The direction of flow departed slightly from the direction of the surface river, being 10 degrees west of south.

At the second station the electrolyte showed itself at both of the downstream wells, being stronger, however, in well F. The velocity here was 6.6 feet a day. Points of special interest are the several steps in which the ampere curves rise, as shown on the electrode circuits for both wells E and F. These indicate different velocities of ground water in the different strata penetrated by the wells. The well points and well-point extensions being covered with new bright brass gauze in these first tests, the different porous strata registered themselves on the brass gauze by blackened bands caused by the corroding influence of the electrolyte. In the present case there were three distinct zones marked off on the wells, of about 24, 20, and 8 inches each. The velocities in these strata undoubtedly differed from one another, and hence caused the steps in the ampere curve. At both stations 1 and 2 the ground water was artesian in character, rising in the wells about an inch for each additional foot increase in depth. The wells were 16 feet deep and showed about 15 inches of artesian head above the water in the flowing stream.

The third station was established on the San Gabriel River just below the wagon bridge on the Whittier road. A special point of interest at this location is the fact that the river totally disappears in its gravel bed a few rods below this bridge. We hoped to secure some facts concerning the direction and velocity of the disappearing water. A double row of wells was driven across the river bed in three

groups about 33 feet apart, as shown in fig. 32. All of the wells, except a group near the left bank, pumped very poorly and were evidently in very tight material. The group of wells near the left



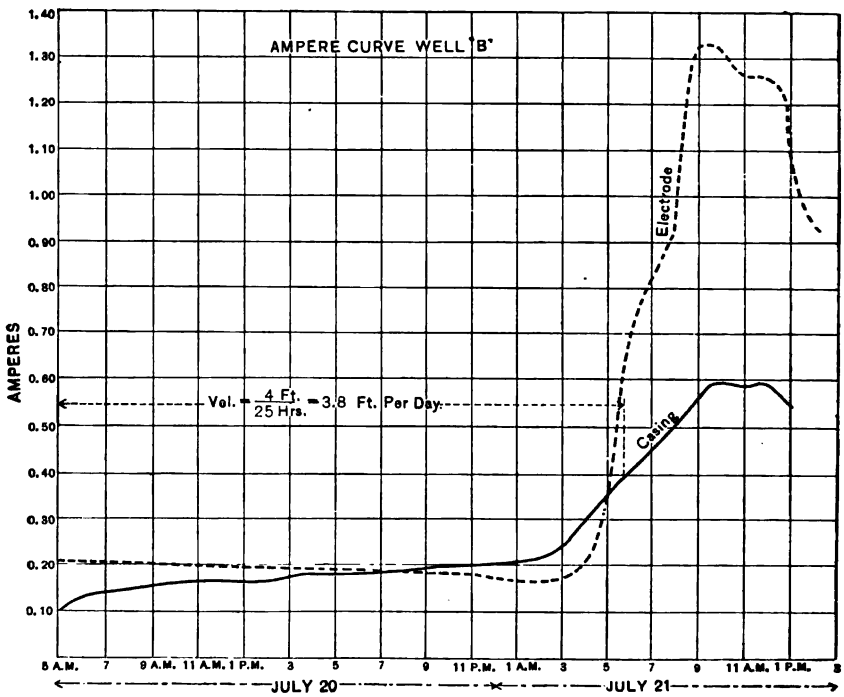



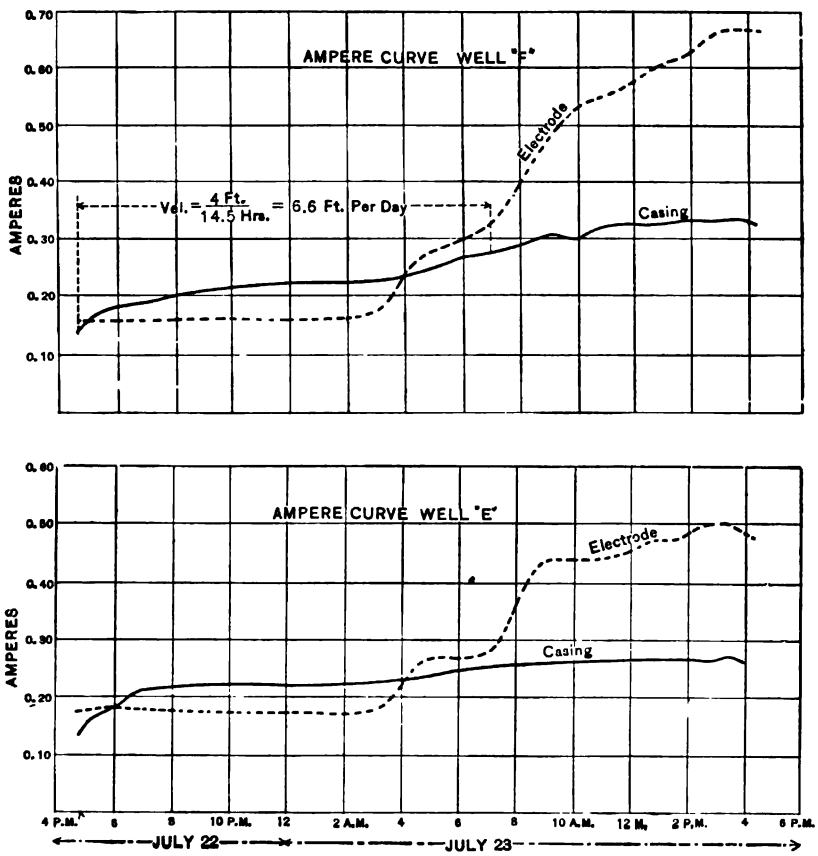

FIG. 31.—Diagrams showing the velocity and direction of flow of the

bank consisted of one upstream well, E, and two downstream wells, F and G. These wells evidently penetrated two different strata of water, as a velocity of 48 feet a day was observed between E and F,

while a second result was strongly developed, indicating a velocity between E and G of 4.8 feet a day. This latter rate was due to the lower stratum of water, whose direction of motion crossed at an angle of 35° that of the upper current of disappearing river water. Further observations at this point were rendered impossible by the breaking of a dam some distance above the station, which completely flooded the wells after the above observations had been made.

The fourth station was established in a walnut grove on Temple's ranch, near the main road from El Monte to Downey. This location is about half way between the two bluffs of the narrows. The group consisted of four wells, and a velocity was found to be rather low, 14 inches a day. The direction of flow was due south.

The fifth station was on the bank of the San Gabriel River, just




underground water at the narrows of the Rio Hondo, stations 1 and 2.

above the head works of the Ranchita and Los Nietos ditches. The velocity determined was 5.3 feet a day, in a direction due south, making an angle, however, of about 45° with the direction of the surface

stream at the same point. The direction of flow and ampere curve are shown in fig. 4.

The cross section of the alluvial deposits at the narrows of the Hondo and the San Gabriel is about 10,000 feet wide and probably does not exceed 600 feet in depth. If we assume that the porosity of the underflow gravel is 33 per cent and that the average velocity of the ground water is 10 feet a day, the resulting estimate of the amount of water which passes underground through the narrows is 230 second-feet, or nearly four times the flow of the surface streams. This is undoubtedly a maximum estimate, as there is no indication that the average velocity is as high as 10 feet a day. Four feet a day may be assumed as a fair minimum value of the average velocity. This would correspond to a total underflow of 92 second-feet.

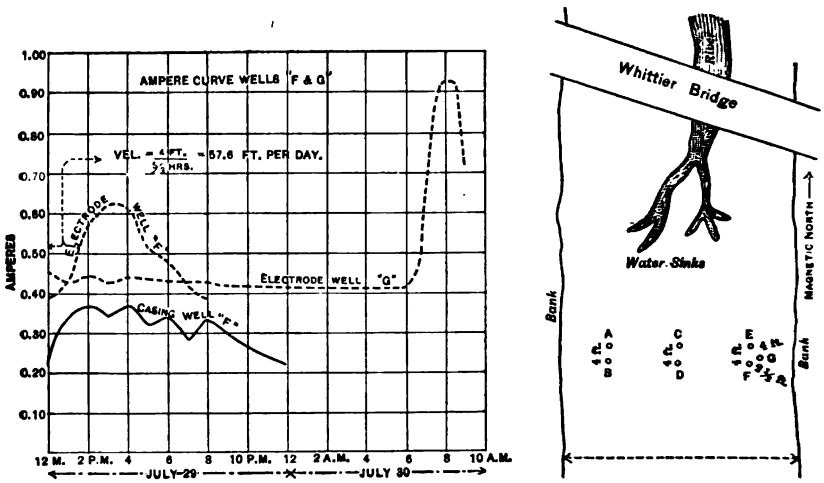



FIG. 32.—Diagram of velocity and direction of flow of underground water at the narrows of the San Gabriel River; station 3.

The measurements established the existence of a distinct underflow of moderate velocity through the alluvial deposits of the narrows. In low stages of the surface streams the underflow probably represents a drainage from the upper valley in excess of that discharged by the surface streams. The substantial identity of the water of the underflow and the water of the surface streams is proved by tests with the Whitney bridge, so that we may conclude that the original mountain stream appears at the narrows as a composite river, consisting of surface streams bordering both the east and the west bluffs of the narrows, together with a very wide and deep but slowly moving underflow occupying the entire major trough of the valley.

# CHAPTER V.

## MEASUREMENTS OF THE UNDERFLOW AT THE NARROWS OF THE MOHAVE RIVER NEAR VICTORVILLE, CAL.

### CONDITIONS AT THE STATION.

The Mohave River rises on the slope of the Sierra Madre Mountains in San Bernardino County, Cal., its headwaters flowing from elevations of 5,000 to 8,000 feet. After following a general northerly course the stream disappears in the Mohave Desert a short distance below Barstow, Cal. After leaving its mountainous canyon the stream gradually loses water, and for a large portion of the summer its bed is dry for a greater part of its course on the plains. At a point about 16 miles north of its source the river passes through a narrow gorge called the "Narrows" of the river. The granite uplift which forms this gorge constitutes a dam that raises the underflow to the surface, so that within an area that extends from a point a mile and a half above the gorge to a point a considerably greater distance below the gorge the stream is of perennial flow. A view of the narrows of the river is shown in Pl. IX. This gorge is just south of the village of Victorville, Cal., a station on the Santa Fe Railway. The place had been under investigation as a possible site for a dam by the United States Geological Survey during the season of 1899 and previously. Reports on this subject will be found in the Eighteenth Annual Report, United States Geological Survey, Part IV, page 708, and the Twenty-first Annual Report, United States Geological Survey, Part IV, page 471. The permanent dry-season flow of the river at the gorge varies from about 30 to 60 second-feet. On August 15, 1902, the discharge, as measured by J. B. Lippincott, was 33 second-feet. Soundings have been made to bed rock at three different lines across the narrow part of the gorge by the United States Geological Survey. The positions of these cross sections are shown in fig. 33. The river-gage rod of the United States Geological Survey is located on the right bank of the river at the end of line 3. This line was selected as the location for the underflow measurements. The maximum depth to bed rock at this point is 46 feet, as is shown in the approximate cross section given in fig. 34. The material filling the gorge and constituting the bed of it is a coarse angular granite débris of a size somewhat larger than buckwheat. Mechanical analysis of the gravel filling the gorge is given in Table VI (p. 30). Determinations of

the effective size of the gravel by King's aspirator showed a mean diameter of 0.72 mm. The samples of gravel were taken from the

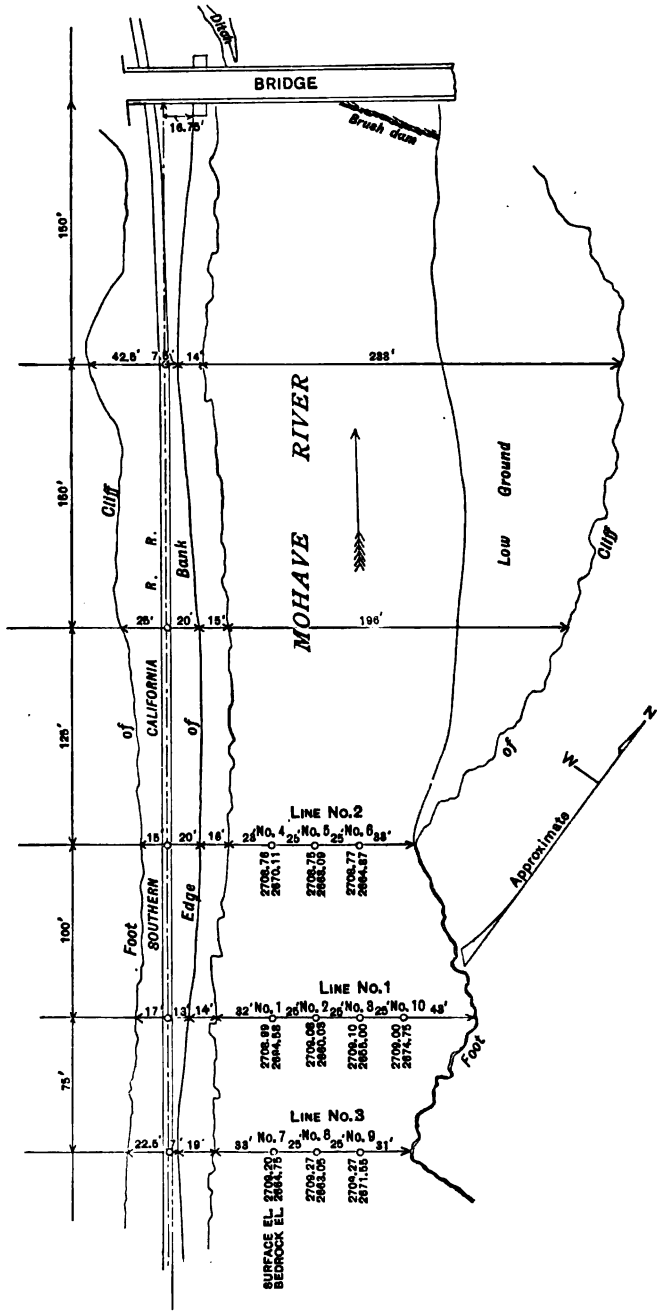



FIG. 33.—Map of the narrows of the Mohave River above Victorville, Cal., showing three lines of test borings made to bed rock by the United States Geological Survey in 1900. Line 3 of these borings coincides with the cross section at which the underflow measurements were made.

surface material. High velocities of the underflow determined at certain depths indicate that there are some streaks of coarser material.

NARROWS OF MOHAVE RIVER.

At time of the underflow investigation; instruments are located in tent at side.

## DESCRIPTION OF EXPERIMENTS.

The site selected for the measurement of the underflow at the upper narrows of the river was in a line extending across the river at right angles to its main course, as shown in the plan given in fig. 33. The water in the river at this point hardly exceeded a foot in depth, but the water spread over the greater portion of the space between the banks, necessitating the construction of a small foot bridge, shown in

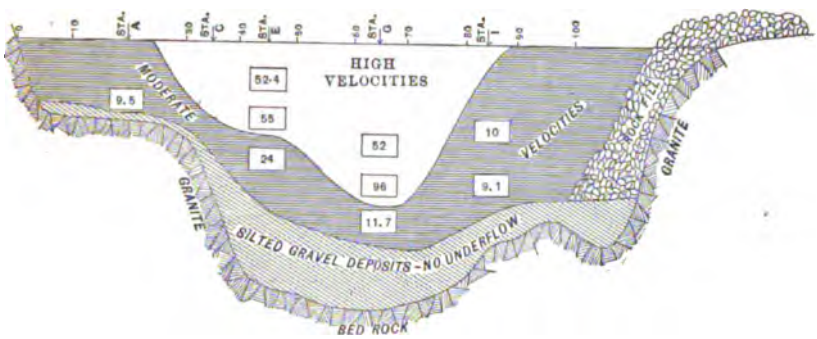



FIG. 34.—Cross section of the narrows of the Mohave River at which the underflow was measured. This line of cross section corresponds to line 3 in the preceding diagram. The rectangles inclosing the figures represent the position and depth at which the underflow was measured. The figures inclosed in the rectangles represent the velocity in feet per day at that point in the cross section.

Pl. X. Another view, Pl. XI, illustrates the method used in putting down the test wells. The double row of test wells, A, B, C, D, E, F, G, H, I, were driven across the river at this point as located on the plan shown in fig. 35. The gorge at this place is only 120 feet wide, and it was at first thought unnecessary to drive more than a single downstream well for each measurement, as it was believed that the

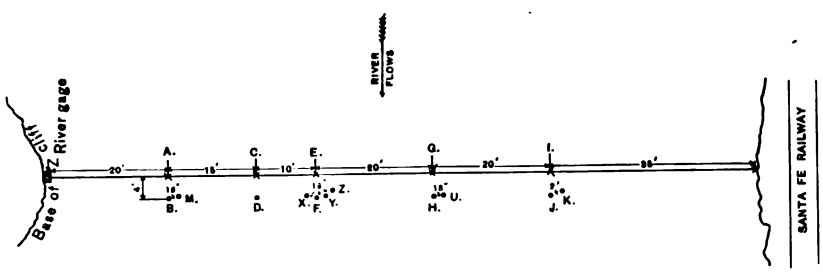



FIG. 35.—This plan shows the position of the various test wells used in the underflow investigation. The principal line of test wells corresponds to line 3 of fig. 33.

underflow must move through the gorge in a very direct course. It was determined, however, after first salting the upstream wells, that the ground waters must be moving through the gorge at this point at a slightly different direction from that of the surface waters, as absolutely no results could be obtained from the wells as first arranged. Accordingly, directional wells M, X, Y, Z, U, K were driven as

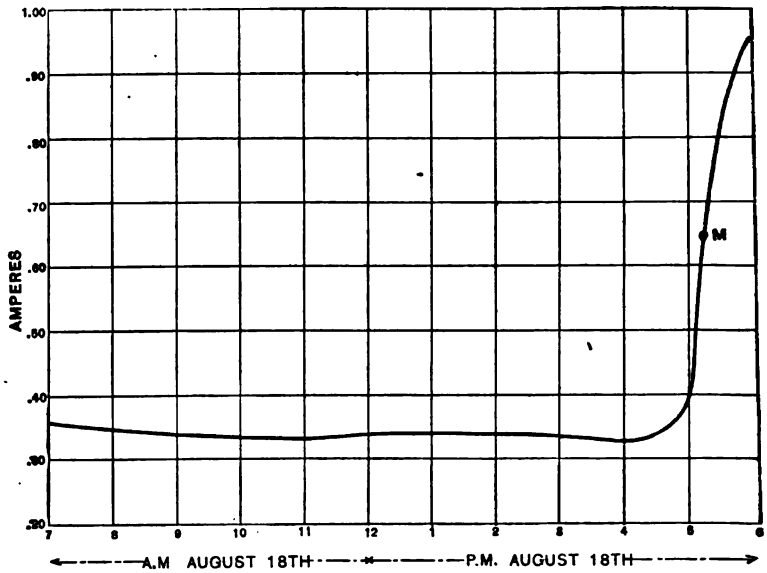



FIG. 36.—Diagram showing the velocity of underflow at narrows of Mohave River, Station A.

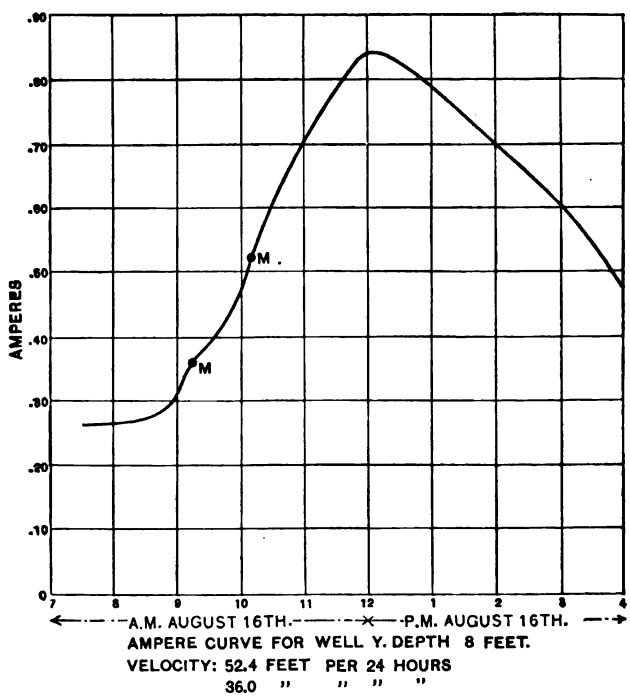
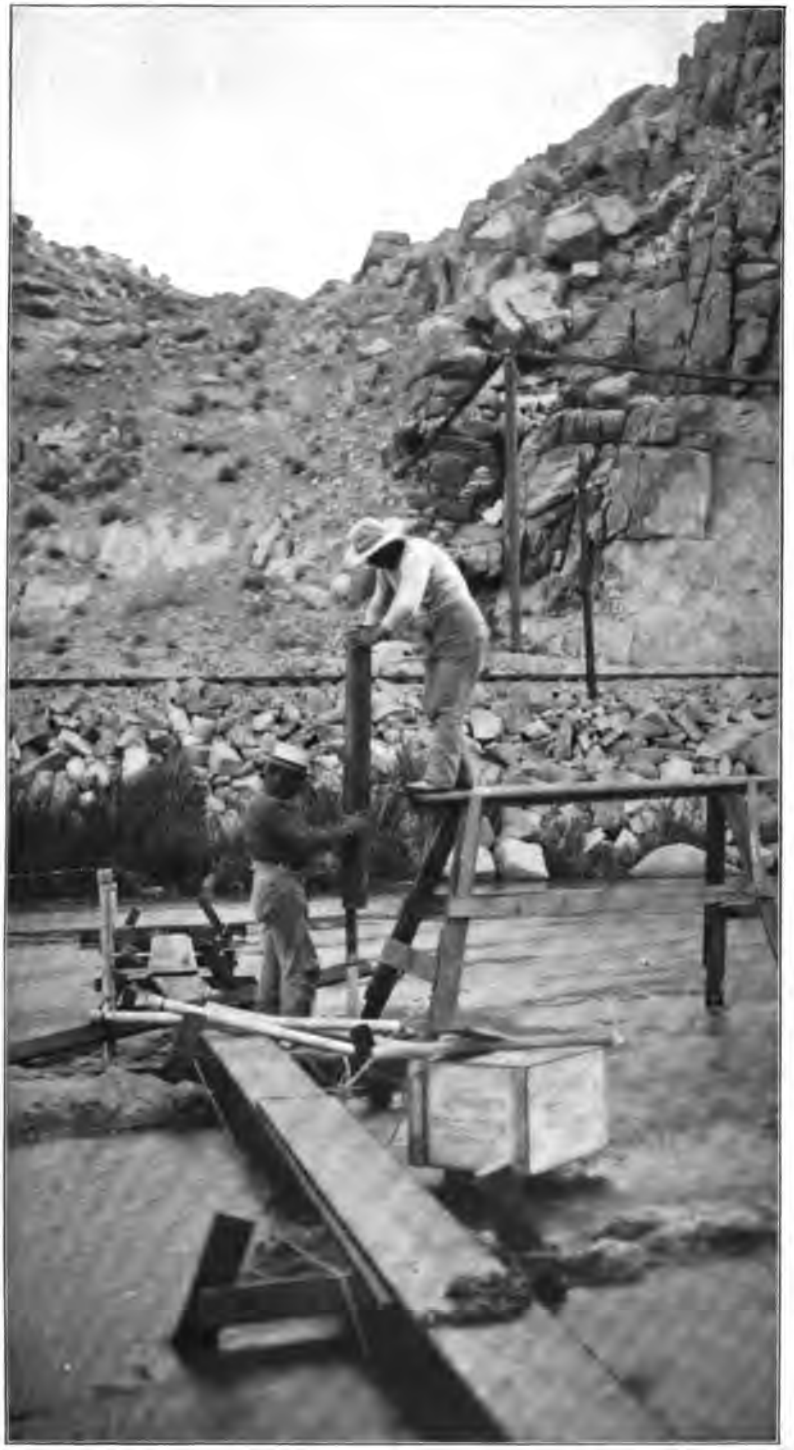



FIG. 37.—Diagram showing velocity of underflow at narrows of Mohave River, station E.

DRIVING WELL G AT UNDERFLOW STATION AT NARROWS OF MOHAVE RIVER.

Showing shallow character of river at this place during dry season.



DRIVING TEST WELLS AT UNDERFLOW STATION AT NARROWS OF MOHAVE RIVER.

The wooden ram used weighed about 60 pounds.

shown in fig. 35. In order to determine whether a variation in the direction was the cause of the failure to measure the underflow, some preliminary experiments were carried out at the position lettered E, test wells X and Y being driven 18 inches from the well F. After these wells were put in place, the well E was salted. This test turned out to be unsatisfactory also, but a slight rise in the electric current in well Y was noticed, which encouraged the belief that the direction

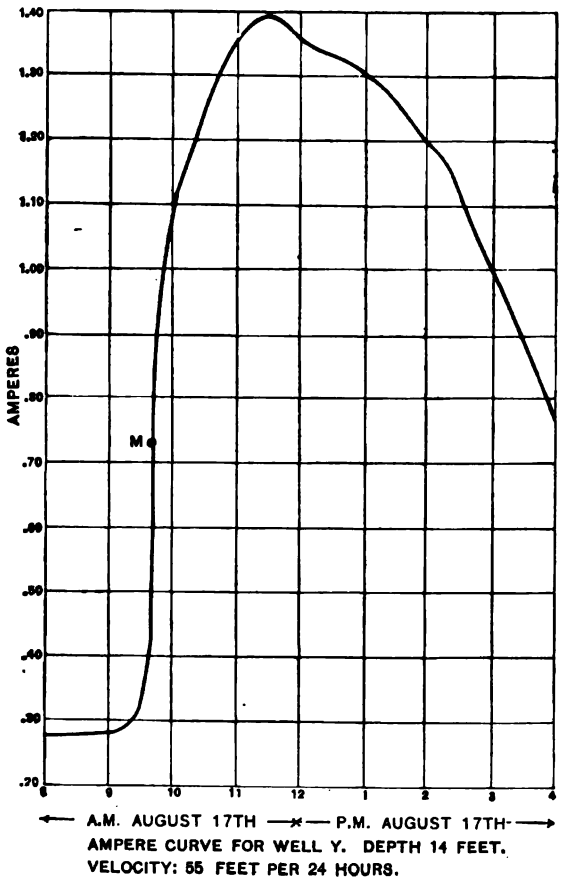



FIG. 38.—Diagram showing the velocity of underflow at narrows of Mohave River, station E.

of flow had been missed in the first test. It was surmised that the ground water might be moving so rapidly as not to give time for the electrolyte to spread sufficiently, and hence was able to pass between two downstream wells 18 inches apart. It was also possible that the direction of the flow was to the left of the new well Y. In order to provide for this contingency, the well X was pulled and redriven in the position indicated by the letter Z, 18 inches from Y.

If it were true that the motion of the ground water of the underflow might be so great that the electrolyte used in well E would not have time to spread sufficiently so as to be certain of coming in contact with one of two downstream wells 18 inches apart, it would be necessary to modify the method of salting E so as to cause, if possible, a wider path to be traversed by the electrolyte. This was finally accomplished by introducing into the well E, along with the dry sal ammoniac, about 10 per cent caustic soda, or common soda lye. This, of course, brought about a reaction between the two salts in solution, ammonia

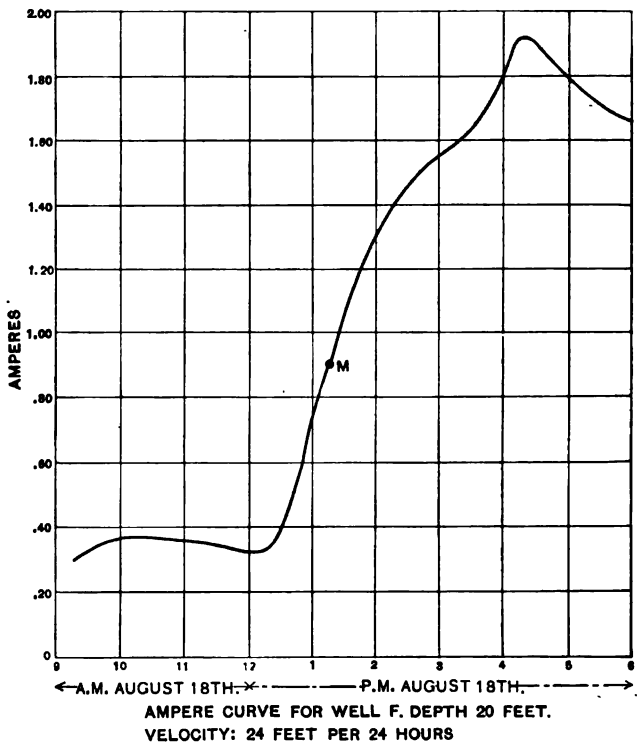



FIG. 39.—Diagram showing the velocity of underflow at narrows of Mohave River, station E.

gas being liberated. It was believed that the liberation of the gas would cause the mixed chemicals to spread more rapidly in the ground waters. This later seemed to be the case, for, carrying out the experiment in this way, it was found that the electrolyte reached well Y, where it showed itself very strongly and just grazed well F. The electrode curve for well Y is shown in fig. 40, which indicated a velocity of ground water of about 52.4 feet for twenty-four hours. This velocity was several times greater than any previously determined, which accounted for the difficulties encountered in interpreting the first failure and in getting the direction of flow. After this expe-

rience all of the upstream wells were salted with the same mixture of sal ammoniac and caustic soda, and no further difficulties were experienced in getting the velocity and direction of flow. At the various stations, A, E, G, I, determinations of velocity were made at various depths, as is shown by numbers inclosed in rectangular lines at appropriate points in the cross section, fig. 34. The pipe casing of well D

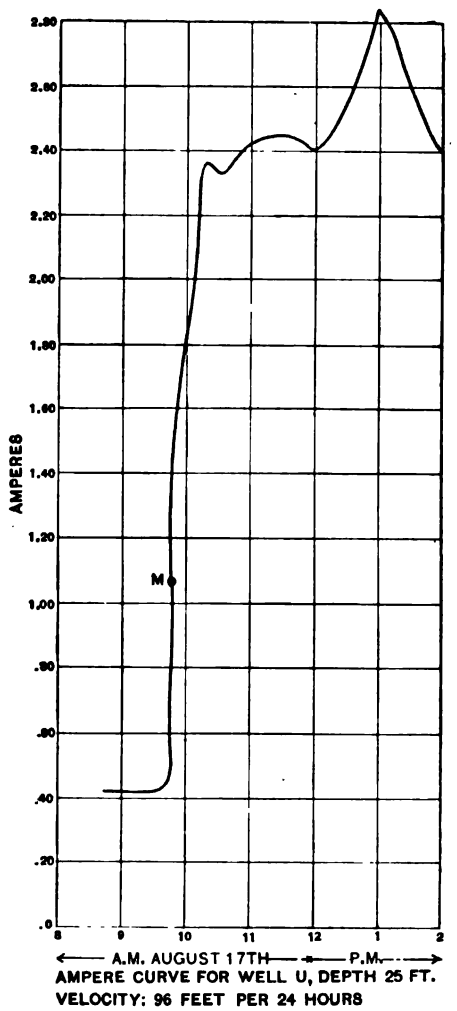



FIG. 40.—Diagram showing velocity of underflow at narrows of Mohave River, station G.

was found to be broken below the ground, and station C was on that account not used.

At depths below the surface not exceeding 25 or 30 feet the gravel of the gorge is completely silted with fine material deposited by the river and is, of course, impervious. At stations E, G, and I, after

the well points were driven a few feet below the point at which the deepest measurements were made the points were completely embedded

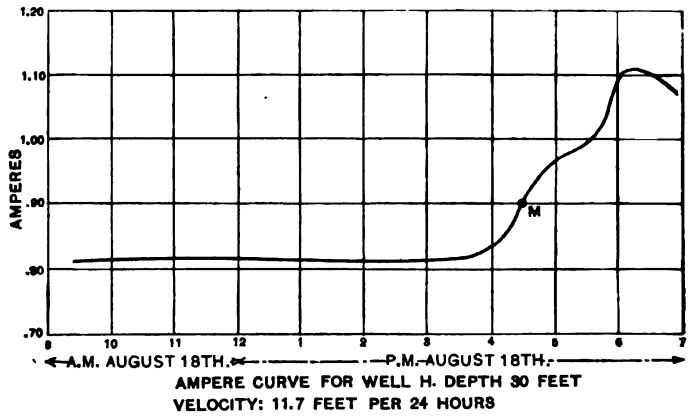



FIG. 41.—Diagram showing the velocity of underflow at the narrows of Mohave River, station G.

in the silted gravel and no water could be drawn from the wells with an ordinary pump. It was therefore very plain that the underflow of

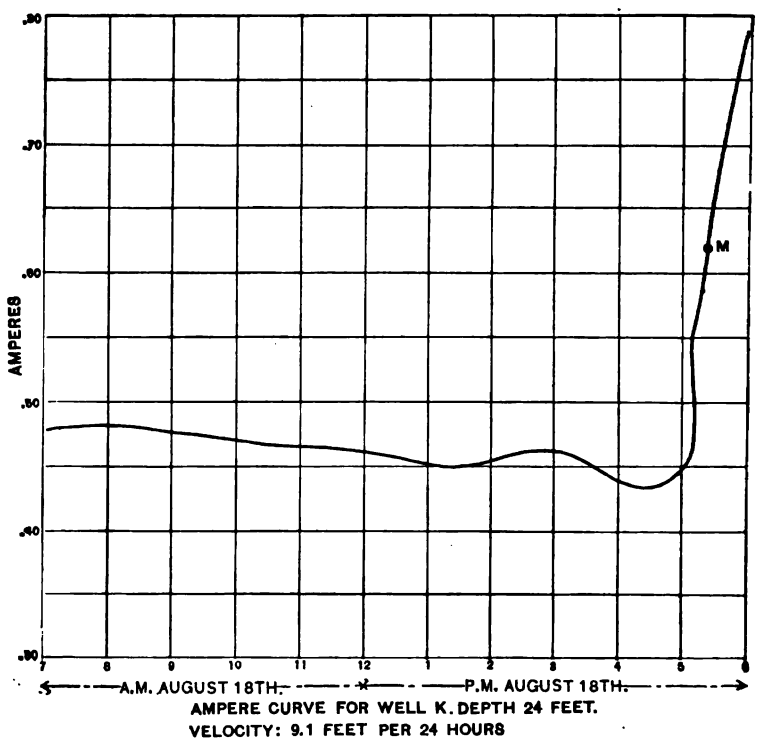



FIG. 42.—Diagram showing the velocity of underflow at the narrows of Mohave River, station I.

the gorge was confined to a depth not exceeding about 30 feet. All of the velocities determined in the clear gravel of the gorge ran very

high, three of them exceeding a velocity of 50 feet for twenty-four hours. Taking Schuyler's figures for the area of the cross section of the gorge, 4,160 square feet, and assuming a mean velocity of ground water in the entire section of 50 feet for twenty-four hours, and estimating the porosity of the gravel at 33⅓ per cent, the total underflow in the gorge will be found to be less than 1 second-foot. This must be understood to be a maximum estimate. The underflow probably does not exceed 300,000 gallons for twenty-four hours. The gradient of the water plane at and above the gorge is almost exactly 20 feet to the mile.

The reproductions of photographs shown herewith illustrate the method of driving the wells used and show the small footbridge and the test wells that were put in place during the investigation. The tent appearing at the left of the cut contained the instruments from which wires were led to the various test wells (Pl. IX).

## QUALITY OF THE WATER.

The quality of the water in the surface stream and in the underflow of the Mohave River at the narrows was determined by tests with the Whitney electrolytic bridge, and the amount of chlorine in the water was determined by titration. The water is remarkable as a desert water for its unusual softness, being very much softer than the usual water found in southern California, as at Los Angeles and neighboring points. This softness is undoubtedly due to the insoluble character of the granitic deposit through which the water flows after leaving its mountain source. It should be remembered that both the surface water in the stream and the underground waters at the location of the narrows of the Mohave River has been flowing in a ground-water stream for 10 or 12 miles of its course. As all of this water reaches the narrows by passing underground for a considerable distance, the results of the few tests made, given herewith in Table X, are of considerable interest.

TABLE X.—*Quality of the water in the river and in test wells at the narrows of the Mohave River.*

[Total solids were determined with the Whitney electrolytic bridge.]

| Well. | Date (August, 1902). | Depth in feet. | Temperature, ° F. | Resistance in ohms. | Chlorine, pts. per 100,000. | Total solids, pts. per 100,000. |
|---|---|---|---|---|---|---|
| A | 10 | 8 | 72 | 1,125 | ..... | 14 |
| B | 19 | 12 | 67 | 1,150 | 2.51 | 15 |
| C | 10 | 16 | 71 | 1,275 | ..... | 12 |
| F | 10 | 7 | 72 | 1,150 | 1.77 | 13 |
| G | 10 | 20 | 70 | 1,300 | ..... | 12 |
| H | 10 | 20 | 70 | 1,300 | 1.25 | 12 |
| H | 15 | 25 | 67 | 1,460 | ..... | 11 |
| J | 10 | 14 | 72 | 1,250 | 1.77 | 12 |
| Z | 15 | 8 | 72 | 1,200 | ..... | 12.5 |
| River water | ([a]) | ..... | 67 | 1,200 | 2.01 | 13.5 |

[a] Aug. 10, 7 a. m.

It will be noticed that the temperature of the water from the deeper wells was somewhat lower than that near the surface, and the deeper water also appeared to be somewhat softer. The temperature of the ground waters remained nearly constant at the various depths, but the stream water showed very marked fluctuations in temperature, as would be expected in a shallow desert stream. The temperature of the stream water taken in the morning was always low. The temperature at 7 a. m. August 10 was 67° F., which was the usual morning temperature. During the day the temperature would rise, the extent of the rise depending upon the character of the day, temperatures as high as 82° being not uncommon. On cloudy days the temperature remained low. It will be noted from the table that the temperature of the surface stream was lower than the temperature of the upper underflow waters at night, and warmer than these waters during the daytime. This is already accounted for by the fact that the surface waters rise from the underflow but a mile or so above the narrows, the surface stream, of course, representing merely the surplus of underflow waters as the ground water approaches the narrows.

# CHAPTER VI.

## MEASUREMENTS OF THE RATE OF UNDERFLOW ON LONG ISLAND, NEW YORK.

### CONDITIONS EXISTING AT THE STATIONS.

The following determinations of ground-water velocities were made along the south side of Long Island, between the villages of Freeport and Massapequa. These places are located about 6 miles apart, on the Montauk division of the Long Island Railroad, which between these points runs nearly east and west and is about 1 mile north of the edge of the extensive salt marshes which border the Atlantic Ocean.

Freeport is about 24 miles from Brooklyn Bridge, and Massapequa, 6 miles east of Freeport, is within 2 miles of the western line of Suffolk County.

Within the 6-mile stretch above mentioned the city of Brooklyn has five pumping stations, drawing water from extensive batteries of driven wells. The names of these stations, from the west, are: Agawam, Merrick, Matowa, Wantagh, and Massapequa. There is a brick conduit on the north side of the right of way of the Long Island Railroad, into which the water from the pumping station is discharged, carrying the water by gravity to a pumping station at Milburn, just west of Freeport, where an additional lift sends the water into the city of Brooklyn. The five driven-well plants above mentioned are used for auxiliary supply in the summer months, the period of use extending usually from July to December, but varying with the rainfall and other climatic conditions.

Within the 6 miles from Freeport to Massapequa the conduit crosses several small surface streams, four of which have been ponded and their waters gated into the conduit. These surface waters flow into the conduit the year round, the driven wells constituting the auxiliary supply.

The particular district under discussion was selected as the object of study because, in the first place, the region seemed typical of conditions on the southern side of the island, and, secondly, because the ground water was substantially in normal condition, owing to the fact that the driven-well plants had not been operated since the previous December. The purpose of this work was to determine the principal facts concerning the underground drainage of the island, so that a preliminary basis could be secured for an estimate of the amount of ground water available for municipal supply.

The determination of ground-water velocities was made at certain selected stations or localities, following, in general, an east-west line. These stations were confined, for the most part, to the highways or other public lands. This restriction did not interfere materially with the selection of the best sites for the work. One set of stations was placed south of the railroad and just north of the line of wells of the driven-well stations, it being considered of importance to measure velocities in the immediate neighborhood of the pumping plants both before and after pumping had commenced. Other stations were located north of the railroad and conduit, out of range of an extensive influence of the pumping plants.

The 6-mile line from Freeport to Massapequa is, as has been stated, about 1 mile distant from the edge of the tidal marshes bordering the Atlantic Ocean. North of this line for a distance of 9 or 10 miles the natural surface drainage of the land is toward the south, the slope for nearly 8 miles of the distance being very uniform and in amount almost exactly 15 feet to the mile. This drainage plain is not only very flat and unbroken, but the surface conditions are exceedingly favorable for the absorption of a large percentage of the rainfall. The soil for the most part is coarse and sandy and very porous. The slope of the water plain is somewhat less than that of the surface of the land, being approximately 10 or 12 feet to the mile. The underground drainage is in general toward the south, the main east-west underground watershed probably coinciding within a mile or two with the surface watershed. The average rainfall is about 44 inches, a very large portion of which enters the ground.

In the localities where the test wells were bored the material was, for the first 30 to 40 feet, yellow sand and gravel, quite clean and uniform, but growing finer with the depth. The first 20 feet below the water plane seemed in every case to be of high transmission capacity, and the material below this level was usually of increasing fineness, finally changing into a fine, dark-colored, micaceous sand. At a depth of 40 to 60 feet a compact layer of clayey and bog-like material was often met, and in driving the test wells into and through this layer the water rose continuously in the wells until a marked artesian head was developed. Immediately below this compact layer good sands were again encountered.

In the report on New York's water supply made by John R. Freeman in the year 1900, it is stated as probable that this layer of clayey material referred to above is distributed as a wide and practically unbroken sheet lying 40 to 60 feet beneath the surface of the south-sloping drainage plain of the island.

One of the objects of the measurement for ground-water velocities was to determine whether or not there was a considerable southerly movement to this water in the sands and gravels above the supposed

clay sheet, and to determine the order of magnitude of such a movement if it existed. Whenever there exists in any drainage area a body of ground water which does not escape into the beds of surface streams as seepage water, but continues a seaward course through the sands and gravels quite independent of the surface streams, this moving sheet of water is known as the "underflow." One of the problems was, therefore, to determine whether or not a true underflow existed in this part of Long Island, and to learn something of its magnitude if it was found to exist. Another problem was to discover, if practicable, if any part of the underground drainage existed below the bed of clay; in other words, it was sought to determine whether the underground drainage consisted only of a surface zone of flow, or whether a deeper zone, or possibly several deeper zones of flow, were also present.

In respect to the first problem above mentioned—the existence of an underflow—there can be no question that a true underflow of considerable importance exists within a depth below the surface of 40 to 50 feet. In practically all of the stations established a good movement was found to exist, having a strong southerly component, and surprisingly free, in many cases, from the influence of neighboring surface streams. The velocity near the surface, 16 to 24 feet below the water plane, ran as high as 5 to 12 feet per day. At greater depths of 30 and 42 feet, respectively, the velocities were in each case about 15 inches per day. At station 9 the sand was so fine at a depth of 45 feet that it could not be prevented from running into the bottom of the well above the top of the well strainer so that the wells could not be used.

The existence of a deep zone of flow was also established. At station 15 clay was encountered at a depth of about 44 feet. These wells were driven to a depth of about 62 feet, when an artesian head of about 30 inches developed. A measurement was then made, the screens on the wells being just below the impervious layer. A velocity of 6 feet a day was found to exist in a direction about 10° west of south. The rate of flow at the same point just above the clay was only 18 inches a day, so that a true "deep zone of flow" undoubtedly exists at this point. This result, although very important, was not surprising, as it had already been well established by the work of Mr. A. C. Veatch and others, of the United States Geological Survey, that the clay layer, formerly supposed to be of wide expanse and quite unbroken, is, as a matter of fact, absent over considerable areas of the island, so that no reason exists why a part of the underground drainage should not exist below this impervious bed. It is strongly urged that further measurements below the clay be made. Measurements made some distance to the east of the present work, say, in Suffolk County, would be of especial value in indicating the areal extent of this deep zone of flow.

The surface zone of flow of the underground waters is probably divided into a number of drainage areas, although it is exceedingly doubtful if the underground drainage basins coincide very closely with the drainage areas of the surface streams. In general, the velocities seemed to increase from west to east, the lowest velocities, however, corresponding to a middle area, where the yellow gravels contained a quantity of fine, clay-like silt. The Wantagh area seemed to have the largest underflow. It would be exceedingly interesting to have series of measurements extending eastward into Suffolk County. By increasing somewhat the number of stations in

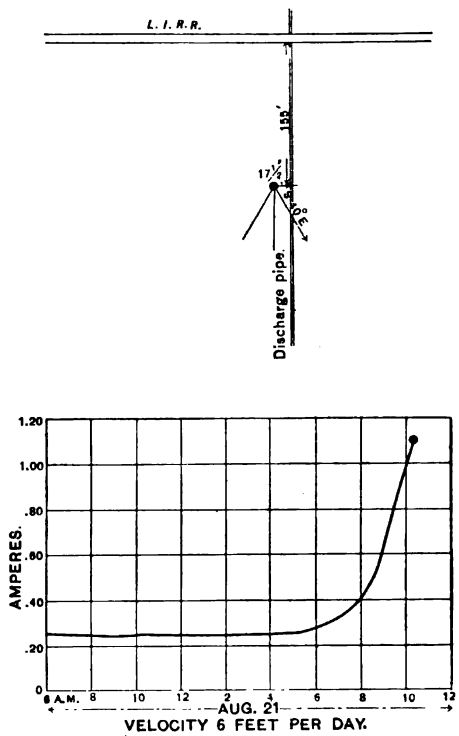



FIG. 43.—Diagram showing velocity and direction of the flow of underground water at Wantagh pumping station (station 2 X). Velocity, 6 feet a day, S. 40° E. This velocity was determined while pumps were drawing water from the wells of the driven well plant at a rate of 4,366,000 gallons per twenty-four hours. No velocity detected when not pumping.

the area already covered and comparing with results from drainage areas in Suffolk County, a comparative study of underground drainage systems would result which ought to have much value in planning sources of supply for Brooklyn.

The details of the measurements are given in the reports on individual stations contained in Table XI. The locations of the stations are shown in fig 57, and the curves of electrical current for the various stations are given in figs. 5 and 43 to 56.

TABLE XI.—*Underflow measurements on Long Island.*

| Number of station. | Velocity of ground water; feet a day. | Direction. | Date, 1903. | Depth of wells in feet. | Kind of point. | No. of text figure. |
|---|---|---|---|---|---|---|
| 1 | 5.5 | S. 10° E | June 21 | 22 | Perforated pipe. | 5 |
| 2 | 2 | ..... | June 24 | 22 | Do. | ..... |
| 2 X | 6 | S. 40° E | Aug. 21 | 22 | Do. | 43 |
| 3 | 2 | ..... | June 26 | 22 | Do. | ..... |
| 4 | 2 | ..... | June 27 | 22 | Do. | ..... |
| 5 | 6.4 | S. 8° W | June 29 | 22 | Common point. | 44 |
| 5 X | 5.4 | S. 8° W | July 3, 4 | 22 | Do. | |
| 5 Y | 8.0 | S. 22° E | Aug. 19 | 22 | Do. | |
| 6 | 5.0 | S. 8° W | July 1, 2 | 34 | Do. | 45 |
| 7 | 2.6 | S | July 5, 6 | 20 | Do. | 46 |
| 8 | 0.0 | S | July 9, 10, 11 | 21.6 | Open-end point. | ..... |
| 8 | 3.1 | N. 34° W | July 14, 15, 16, 17. | 21.6 | Do. | 47 |
| 10 | 2.6 | S. 37° E | July 17, 18, 19, 20. | 28 | Common point. | 48 |
| 11 | 0.0 | ..... | July 27–Aug. 8. | 22 | Do. | ..... |
| 12 | 1.07 | S. 3° E | July 27–Aug. 1. | 27 | Open-end point. | 49 |
| 13 | 96. | S | Aug. 3, 4 | 16 | Common point. | 53 |
| 13 | 6.9 | S | Aug. 3, 4 | 16 | Do. | |
| 14 | 9.3 | S | Aug. 5, 6 | 17 | Do. | 50 |
| 15 | 1.53 | S | Aug. 6, 7, 8, 9, 10. | 42 | Open-end point. | 51 |
| 15 X | 6.00 | S. 15° W | Aug. 17, 18, 19. | 62.5 | Do. | 52 |
| 16 | 0. | S. 30° E | Aug. 10, 11. | 16 | Common point. | ..... |
| 16 X | 77 | S. 60° E | Aug. 13, 14. | 16 | Do. | 54 |
| 16 X | 11.6 | S. 60° E | Aug. 13, 14. | 16 | Do. | |
| 17 | 10.6 | S. 30° W | Aug. 12, 13. | 20 | Do. | 55 |
| 18 | 1 | S | Aug. 15–21. | 62 | Open-end point. | ..... |
| 21 | 21.3 | S. 50° E | Aug. 18, 19. | 16.5 | Common point. | 56 |
| 22 | 5.6(?) | S. 30° E | Aug. 20, 21. | 16 | Do. | ..... |

## INFLUENCE OF THE RAINFALL UPON THE RATE OF MOTION OF GROUND WATERS.

An excellent opportunity was presented at one of the stations for noting the influence of a heavy rain upon the velocity of ground waters.

At station 5, Agawam pumping station (see figs. 58 and 44), the upstream well, A, was salted at 9.45 a. m., June 29, 1903. Between

9 a. m. and 1 p. m. nearly 3 inches of rain fell, so that the heavy precipitation coincided with the early part of the ground-water measurements. The velocity found was 6.4 feet a day. On July 3 the experiment was repeated, there being no rain in the intervening time. The velocity found in the second trial was 5.3 feet a day. The change in velocity was undoubtedly due to the enormous rainfall during the first experiment. Part of the high velocity during the rain storm may be attributed to the low barometer accompanying the storm, but part

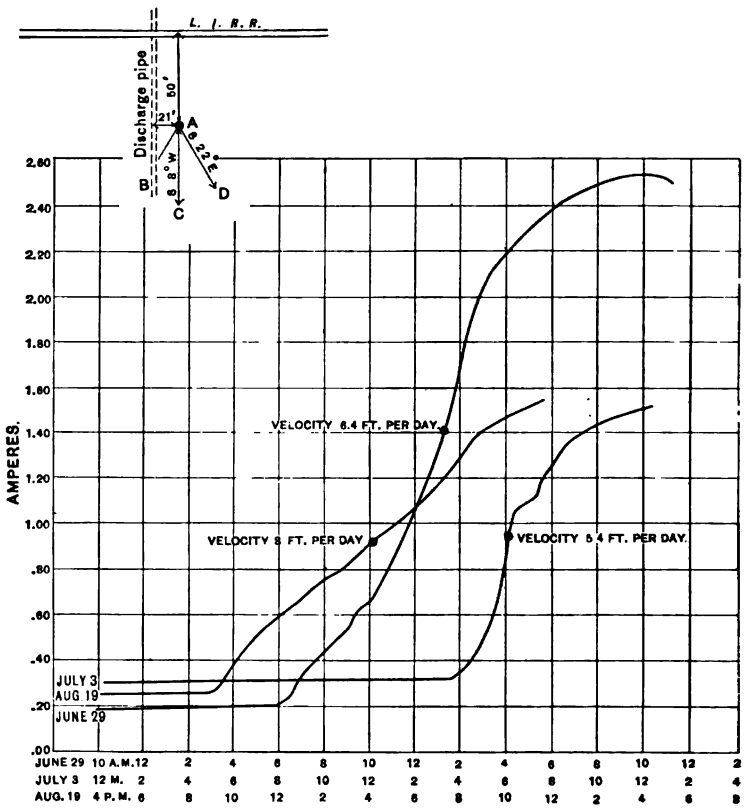



FIG. 44.—Diagram showing three determinations of velocity and direction of flow of underground water at Agawam pumping station (station 5). Normal velocity of ground water, 5.4 feet a day, S. 8° W. Velocity during heavy rain, 6.4 feet a day, S. 22° E. Velocity while pumping from the lines of driven wells, 8 feet a day, S. 22° E.

of it should be assigned to the increased head of ground-water pressure and to increased load carried by the soil, caused by the heavy rainfall upon the receiving area.

As is shown in another place[a] ground waters move very much as electricity is conducted in a good conductor, the most striking quality being an almost complete absence of true inertia in ground-water motions. The motion of a mass of ground water, even for the highest

[a] Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1899, p. 331.

velocities, is so slow that the resistance to an accelerating force represented by the inertia of the ground water is almost nothing when compared with the component of the retarding force due to the capillary resistance in the small pores of the sand or gravel. Actual computation will show that in a uniform sand of diameter of grain of one-half millimeter, the ground water will reach within 1 per cent of its final maximum velocity due to a sudden application of pressure, or head, in approximately thirty seconds of time. This surprising result of the theory of ground-water motions receives a very striking verification in the increase in velocity noted during the rainstorm as described above.

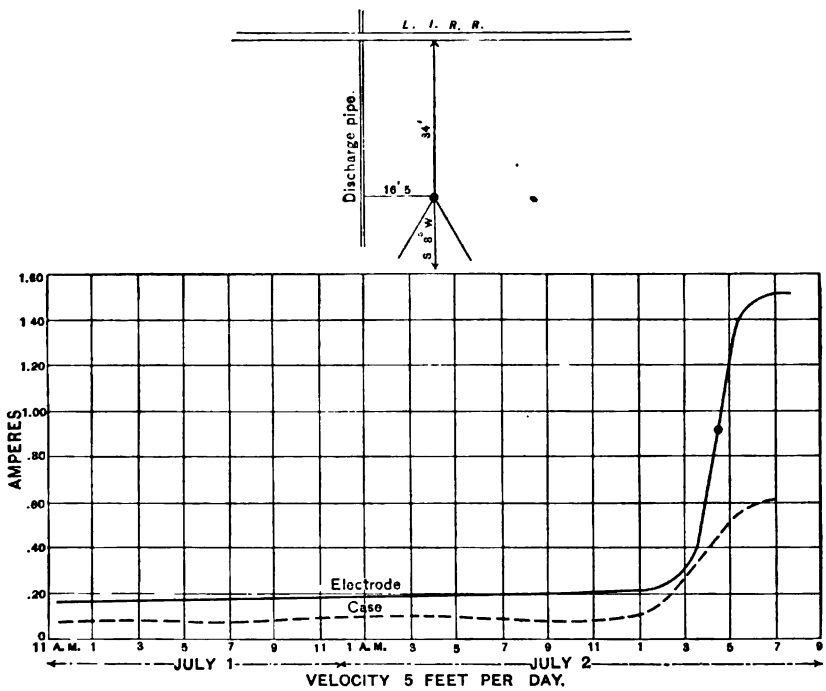



FIG. 45.—Diagram showing velocity and direction of flow of underground water at Agawam pumping station (station 6). This station is located near station 5, but wells were 12 feet deeper.

These results have important bearings on our knowledge of ground-water phenomena in the neighborhood of a well. They indicate that the velocity of the ground waters in the neighborhood of a well reaches a maximum value soon after pumping is commenced. The gradual formation of the cone of depression near the well shows that there must be a progressive augmentation of the initial velocity of the ground waters toward the well. Nevertheless, the rate of depression of the water table is so slow that the ground-water motion established soon after the pumping has begun is substantially the same as its value after prolonged pumping. These remarks have their most

important bearing upon the phenomena of the mutual interference of wells. The interference of one well with the supply of a neighboring well is thus seen to come into existence almost instantaneously and need not wait for the establishment of a cone of depression of large area. The phenomenon of the cone of depression has much to do with the permanent supply of the well, but has slight bearing upon the proper spacing of the wells or the percentage of interference of one well with another.

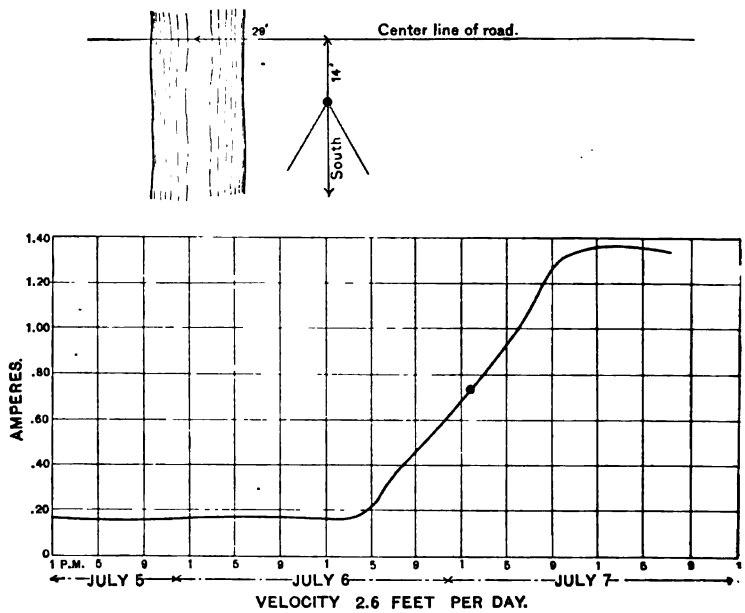



FIG. 46.—Diagram showing velocity and direction of flow of underground water at East Meadow Brook and Babylon Road (station 7). This station is a short distance above Agawam Pond, and the velocity is reduced by the flat water plane due to the presence of the pond. Velocity, 2.6 feet a day, south.

## SEEPAGE WATERS FROM PONDS AND RESERVOIRS.

The work on Long Island afforded some unusually good opportunities of determining the rate of seepage below the impounding dams of some of the storage ponds which the Brooklyn Water Works has established north of the conduit line referred to in the opening pages of this chapter. The batteries of driven wells, which have been placed a few hundred feet south of nearly all of these ponds, were not used during the summer of 1903, as the heavy rains furnished a sufficient quantity of surface water, and the auxiliary supply from the wells was not drawn upon, as usual, during July and August. Station 5 is below the Agawam Pond and somewhat within the line of seepage from the pond, as can be seen by consulting fig. 58. The normal velocity of

ground water at this station is 5.3 feet a day. At station 7, just north of the pond, the velocity was 2.6 feet a day. It seems clear that the natural velocity at these points, if the influence of the dam and pond were removed, would be about 4 feet a day. The velocity at station 6, located but a few feet from station 5, was 5 feet a day at a depth of 34 feet, as compared with 5.3 feet a day at a depth of 22 feet. The dam has the effect of making the water table nearly level in the immediate neighborhood of the pond, and also of greatly augmenting the slope of the water table for a short distance below the pond. The lower velocity above the pond and the higher velocity below the pond correspond

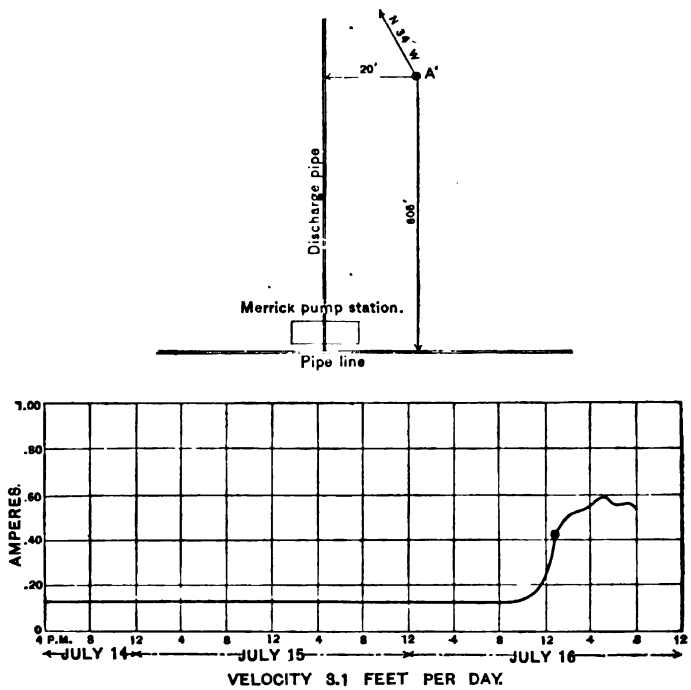



FIG. 47.—Diagram showing velocity and direction of flow of underground water near Merrick pumping station (station 8). The ground water at this point slopes in a northerly direction toward the brick conduit north of the Long Island Railroad. The velocity found was 3.1 feet a day, N. 34° W. The northerly flow at this point is undoubtedly due to seepage into the conduit.

with these facts. When there was no flow over the waste weir of the dam, the flow of the small stream which rises below the dam was measured at the bridge marked A in fig. 58. On July 10 this flow was 1.2 second-feet, practically all of which represented seepage water from the reservoir.

A flow of 1.2 second-feet or 103,000 cubic feet a day represents an amount of water flowing through a bed of sand 30 feet deep and 1,000 feet wide, at a velocity of 1 foot a day, the porosity of the

sand supposedly being equal to one-third. The normal velocity of the ground water is augmented, as shown by the measurement quoted above, by somewhat more than 1 foot a day. The width of the lower end of this pond, or the length of the earthen dam, is about 1,400 feet, so, basing the estimate on this minimum length and on a minimum depth of 30 feet, an augmented velocity of 1 foot a day would give a minimum estimate of the seepage from the dam of 1.6 second-feet. Since 1.2 second-feet are known to actually come to the surface to feed the stream below the dam, it is evident that this estimate of seepage is a minimum. It seems evident that a considerable volume of

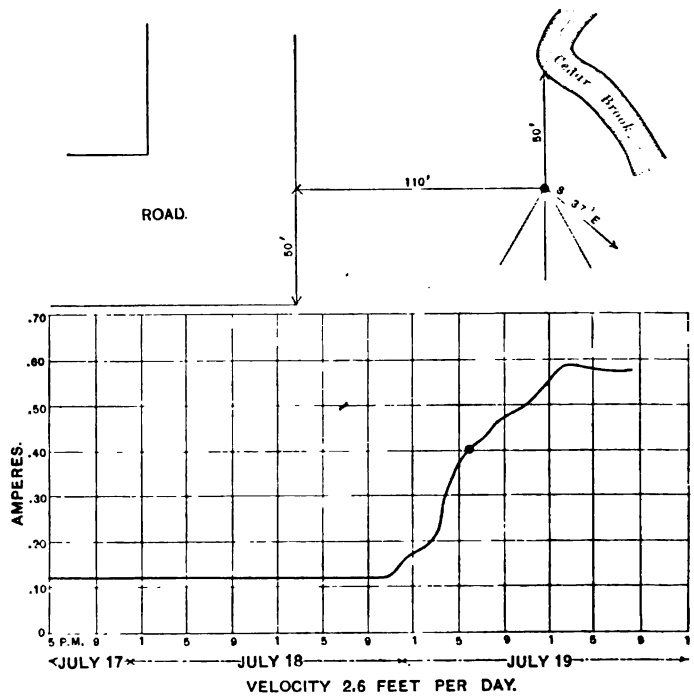



FIG. 48.—Diagram showing velocity and direction of flow of underground water at Cedar Brook (station 10). This station is above Cedar Brook Pond. The velocity is 2.6 feet a day, S. 37° E.

seepage water could be recovered by extending the line of driven wells of the Agawam pumping station to the east of the present terminus, a distance of 600 or 700 feet, without serious lowering of the water plane.

A test well was driven in the lower south end of Agawam Pond to a depth of 10 feet to determine the pressure gradient of ground water beneath the surface of the pond. The water in this test well stood about 1 foot lower than the water in the pond itself, showing a slope of the water plane or a hydraulic gradient of 7 feet to a mile.

The gradient of the water plane below the dam—that is, between the dam and station 5—was 17 feet to the mile, so that the velocities to be compared are:

Station 7 above pond; gradient, 7 feet per mile; velocity, 2.6 feet a day.
Station 5 below pond; gradient, 17 feet per mile; velocity, 5 feet a day.

These results check very favorably, especially when it be considered that the gradient above or north of station 7 was probably 10 or 12 feet per mile, which would make the effective gradient at this station somewhat greater than 7 feet per mile.

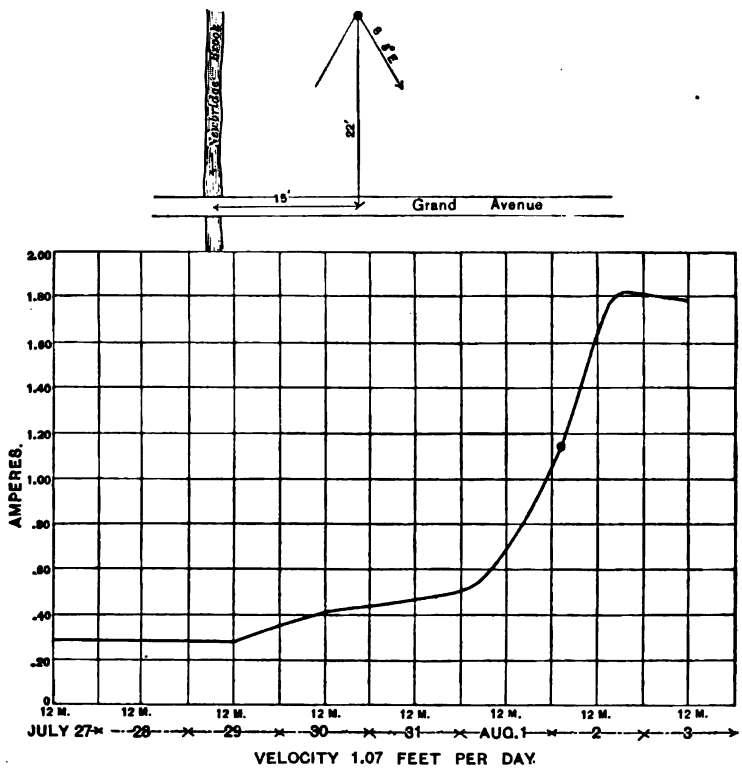



FIG. 49.—Diagram showing velocity and direction of the flow of underground water at Grand Avenue and Newbridge Brook (station 12). Velocity, 1.07 feet a day, S. 3° E. This is the lowest velocity determined on Long Island.

Very striking results were obtained below the dam at the Wantagh Pond, where measurements were undertaken to determine the rate of seepage. The dam of Wantagh Pond runs parallel to the right of way of the Long Island Railroad, about 75 feet north of the road, and has an extreme length of 500 or 600 feet. About 150 feet south of the railroad, downstream from the reservoir, the city of Brooklyn began in 1903 the construction of an infiltration gallery, consisting of a line of 36-inch double-strength tile, laid at a depth of 16 feet below the

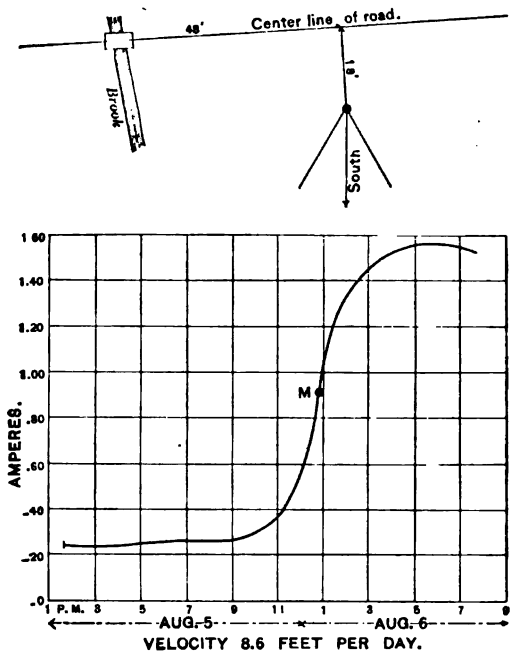



FIG. 50.—Diagram showing velocity and direction of flow of underground water at Bellevue road (station 14). Velocity, 8.6 feet a day, south.

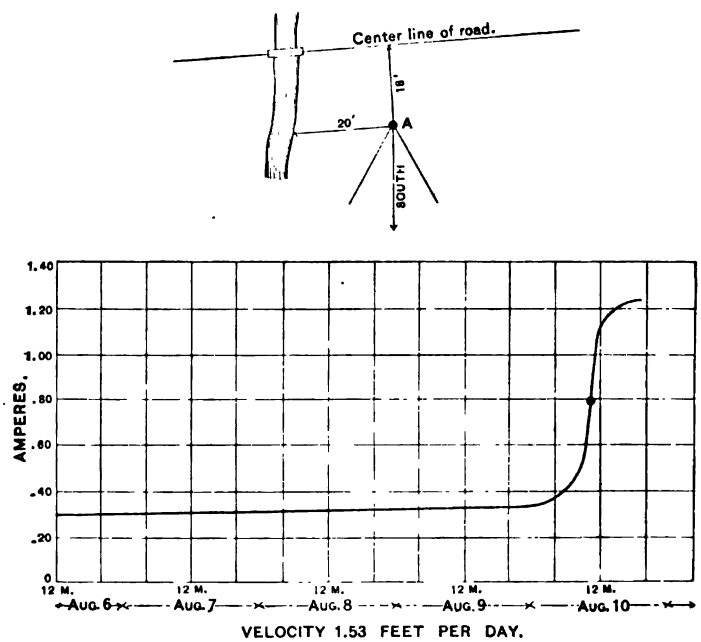



FIG. 51.—Diagram showing velocity and direction of the flow of underground water at Bellevue road (station 15). Velocity, 1.53 feet a day, south.

water plane. It is proposed to extend this gallery for a mile east and west from the Wantagh pumping station. Stations 13, 16, and 17 were established for the purpose of measuring the normal ground-water velocities at the depth (16 feet) of the proposed gallery. Two of these stations are immediately south of the pond and in the apparent direct line of seepage, while station 17 is located slightly east of the edge of the pond and, as seems evident from fig. 59, just on the edge of the main influence of seepage from the ponds. The seepage velocities at stations 13 and 16 turned out to be enormous, the velocity at station 13 being 96 feet a day, south, while at station 16 the velocity was 77 feet a day, the direction being about 30° east of south, the deflection being toward the neighboring stream, as shown in fig. 59. These

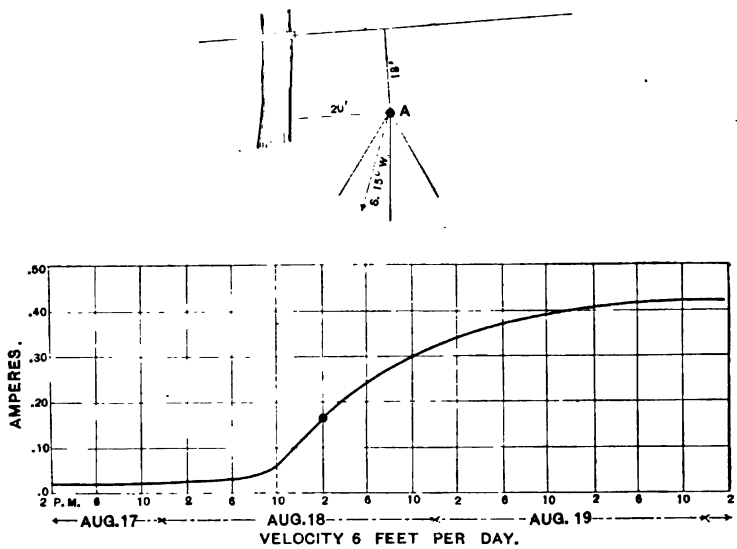



FIG. 52.—Diagram showing velocity and direction of the flow of underground water at Bellevue road (station 15 X). Velocity, 6 feet a day, S. 15° W. This station is the same as station 15, but measurement of velocity was made below a stratum of clay or bog material at a depth of 62.5 feet, 20 feet deeper than the measurement shown in fig. 51.

velocities are the highest the writer has determined. They may be regarded as record-making rates for the horizontal motion of ground waters. Both measurements were made with the recording instruments, and by consulting the curves in figs. 53 and 54 it will be noted that each curve has two maximum points, which must correspond to the velocities in two distinct layers of gravel. The secondary velocity for station 13 was 7.4 feet a day and for station 16, 11.3 feet a day. A very striking verification of the fact that the high movements here found were due to the escape of water from the pond will be noted when the temperatures of the waters in the wells of these stations are compared with the temperatures of the water in the pond and the water

in wells outside of the influence of seepage from the pond. Practically all well water taken from wells on Long Island have temperatures lying between 58° F. and 60° F. In the present case the temperature of water drawn from H. A. Russell's well, 22 feet deep, just west of Wantagh Pond, was 59° F. on August 8, 1903. The temperature of water from well D of station 17, just east and slightly below the pond, was 61.2° F. on August 11, 1903. This well was 20 feet deep, the bottom being at the same depth as the wells of stations 13 and 16. The

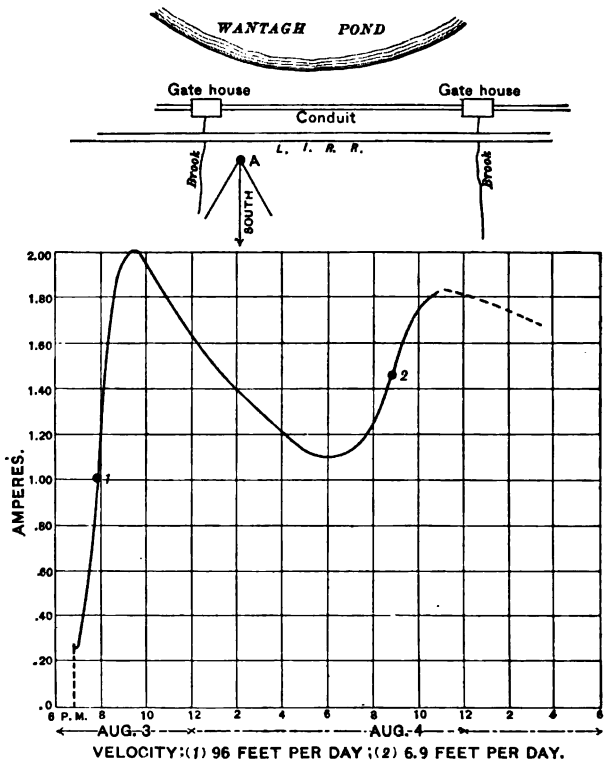



FIG. 53.—Diagram showing velocity and direction of the flow of underground water south of Wantagh Pond (station 13). Two velocities are shown, two different depths. The high velocity, 96 feet a day, is the highest yet determined. Seepage from the pond accounts for the high velocities, 96 and 6.9 feet a day, south. Ammeter chart for this station is shown in fig. 12.

temperature of water in the pond varies more or less, especially the temperature of the surface layer. The temperature of the pond water on August 8, a cloudy day, was 72.5° F., and on July 30, a sunny day, it was 80° F. The temperature of water from the wells of station 13 was 65.8° F. on July 30, and from the wells of station 16 on August 8 was 69.5° F. These high temperatures at stations 13 and 16 show that a large portion of the moving ground water must come directly from the pond, and the rate of motion is so great that the ground

water has not time to be reduced to the normal temperature of the ground.

The velocity at station 17 was 10.6 feet a day in a direction 30° west of south. The temperature of the water was 61.5° F. The ground water at this point is probably not entirely free from the seepage water from the pond. The direction of flow, the velocity, and the temperature of the water all indicate, however, that a considerable

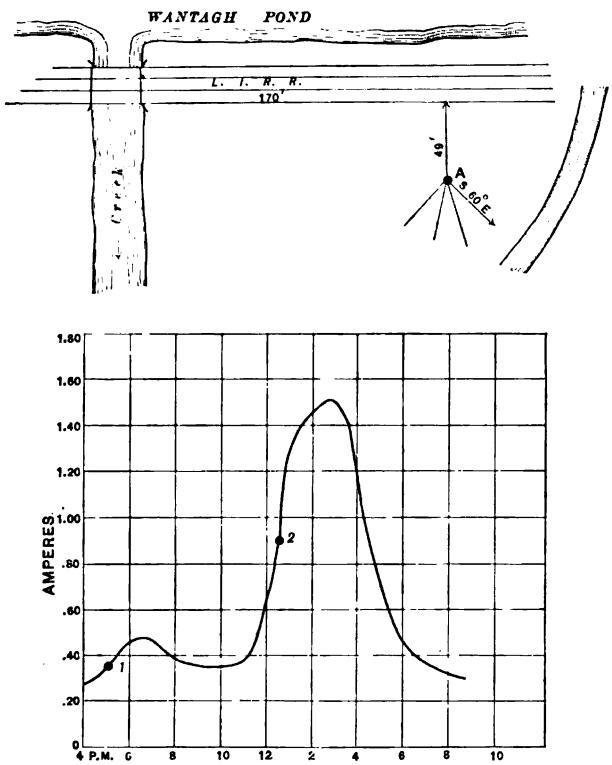



FIG. 54.—Diagram showing velocity and direction of flow of underground water at Wantagh Pond (station 16 X). This station is near station 13, and the curve shows two distinct velocities in different strata. Velocities, 77 and 11.6 feet a day, S. 60° E. The stream just east of the station seems to deflect the direction of flow toward itself.

part of the water is the natural underflow, which at this point is diverted toward the lowland occupied by the streams below the pond.

There can be no doubt but that the proposed infiltration gallery will intercept a large amount of seepage water from the pond, which at the present time runs entirely to waste. The amount of seepage in the first 16 feet in depth is probably somewhat less than 3 second-feet per 1,000 feet of length of cross section, or about 2,000,000 gallons per twenty-four hours.

At station 21, located just above Wantagh Pond, the velocity at a depth of 17 feet was 21.3 feet a day in a direction 60° east of south. This station is near the west bank of the main brook that feeds the pond, and the greater portion of the ground-water at this point percolates into the bed of the stream. The true underflow at this point can be found by taking the southerly component of this velocity, which gives 10.6 feet a day. The temperature of the ground water at this point was 58° F.

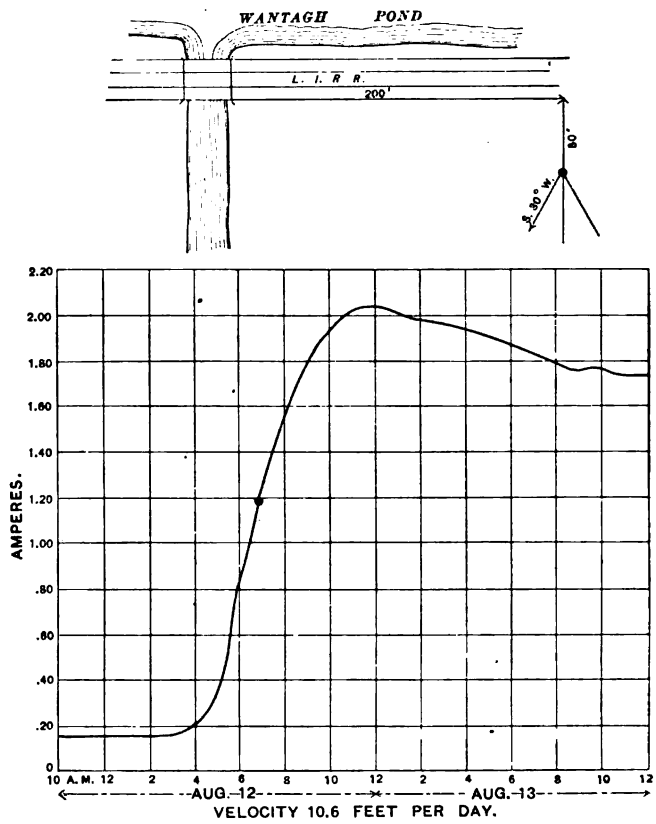



FIG. 55.—Diagram showing velocity and direction of the flow of underground water at Wantagh Pond (station 17). Velocity, 10.6 feet a day, S. 30° W.

The increase of underflow rate at the Wantagh Pond from 10.6 feet a day above the pond to 96 and 77 feet a day below the pond, as compared with velocities above and below Agawam Pond, 2.6 and 5.3 feet a day, respectively, is easily understood when the material constituting the bottom of the ponds is inspected. The material at Agawam is good, the soil being fine and compact, while at Wantagh the bottom of the pond is very sandy, in some places having a closer resemblance to a filter bed than to a puddled floor.

## INFLUENCE OF PUMPING UPON THE RATE OF MOTION OF GROUND WATERS NEAR SOME OF THE BROOKLYN DRIVEN-WELL STATIONS.

Through the courtesy of Mr. I. de Verona an excellent opportunity was furnished the writer of making some observations on the influence of pumping upon the normal rate of motion of ground waters in the neighborhood of some of the Brooklyn driven-well stations. For this special purpose the pumping stations at Agawam and Wantagh, which had been idle since December, 1902, were started up for two days each in August, 1903. Agawam was operated continuously from 7 a. m.,

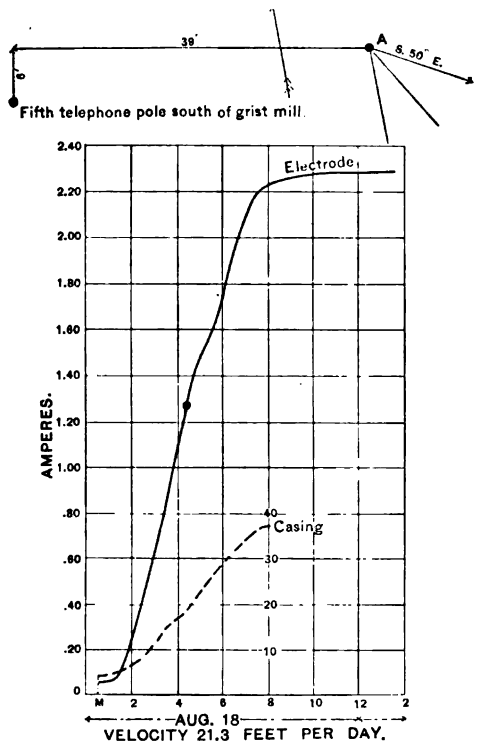



FIG. 56.—Diagram showing velocity and direction of the flow of underground water (station 21). Velocity, 21.3 feet a day, S. 50° E.

August 19, to 7 a. m., August 20. At the Agawam station observations were made at station 5 by means of the recording instrument. Well A was charged at 4 p. m., August 19, or after nine hours of continuous pumping. After this length of time it was expected that the maximum rate of flow of ground water would be established, although, of course, the cone of depression near the wells would still be changing quite rapidly.

Station 5 is 30 feet north of the intersection of the chief suction mains communicating with the line of driven wells and 12 feet east of

the central discharge main (see fig. 58). The depth of the test wells is 22 feet, while the depth of the 30 wells of the Agawam station system varies from 30 to 105 feet.

The rate of pumping during the forty-eight-hour test was very uniform, at an average rate of 2,250,000 gallons per twenty-four hours. The vacuum at the pump was maintained at 24 inches, while that at the first well east of the engine-house was 23.2 inches. The charge of the centrifugal pump was dropped from 4 p. m. to 4.40 p. m.

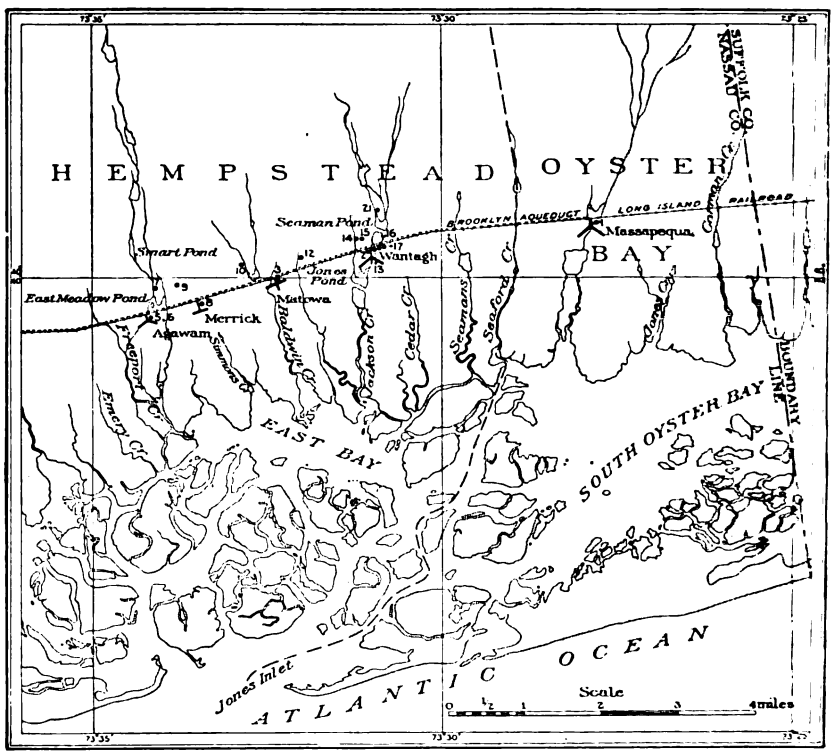



FIG. 57.—Map showing location of overflow stations, at which determinations of the rate of flow of underground water were made on Long Island. The Brooklyn driven-well pumping stations are located on the south side of the railroad and are named, from east to west, Massapequa, Wantagh, Matowa, Merrick, and Agawam.

August 19, during which time the vacuum fell to 7 inches. This was the only interruption during the test.

The velocity determined at station 5 during the test was 8 feet a day in a direction S. 22° E. The normal velocity at this station is 5.4 feet a day, S. 8° W., so that the influence of the pumping was to increase the velocity by 2.6 feet a day, or an increase of about 50 per cent (fig. 44). The actual velocity found and the percentage of increase are both very moderate, and indicate that the pumping station is not making an unreasonable draft upon the ground-water supply at this point.

The 30 wells of the Agawam supply station have screens each 10 feet long, or, altogether about 730 square feet of screen. The maximum velocity of the ground water as it enters these screens must be 1,230 feet a day, since the actual pumpage was 2,250,000 gallons or 300,000 cubic feet per twenty-four hours. The mean velocity in the area (10 by 1,500 feet cross section) immediately drawn upon by the wells was about 30 feet a day. The reduction of this rate to 2.7 feet a day represents a ratio of reduction of 11, which could be taken care of by a depth of 110 feet in the water-bearing gravels, without going outside of the 1,500 foot east and west line of the driven wells.

To put this in another way: the daily pumpage of 300,000 cubic feet of water could be supplied by the normal rate of motion of the ground

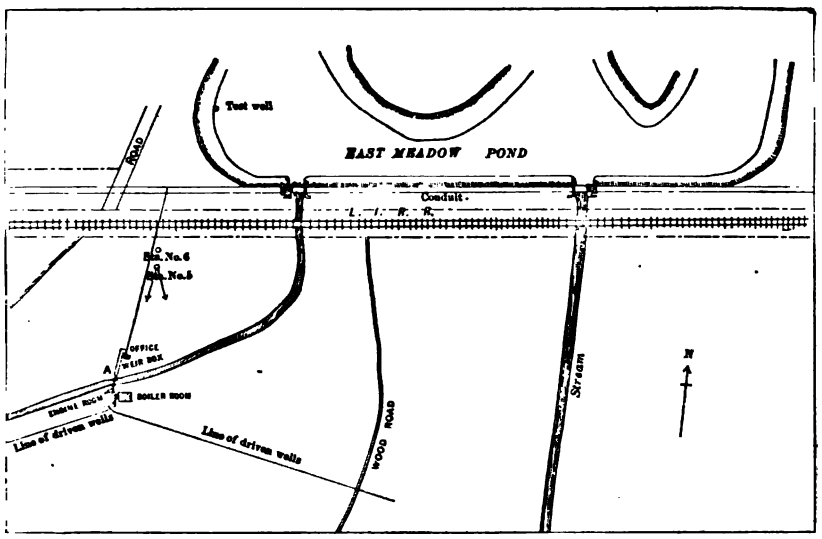



FIG. 58.—Map showing location of stations 5 and 6 with reference to Agawam pumping station and East Meadow Brook Pond. The surface stream was gaged at the bridge marked A. The normal direction of ground-water motion at station 5 was S. 8° W. During a heavy rain, and also when the pumps were drawing water from the lines of driven wells, the direction of flow changed to S. 22° E., as shown by the arrows drawn from station 5.

water at this point (5.4 feet a day) through a cross section of 510,000 square feet, or, say, 100 feet deep by 1 mile wide. To supply this amount of water, if removed from the ground on each of the three hundred and sixty-five days in a year would utilize 1 foot of rainfall on 12 square miles of catchment area. These amounts are not excessive. The rate of removal of ground water at the Agawam station must therefore be regarded as exceedingly moderate.

The observations at Wantagh pumping station were made on August 21 and 22. The pumping at this station began at 7 a. m., August 21, and continued forty-eight hours at the uniform rate of 4,366,000 gallons per twenty-four hours. The water at this station is drawn

from 48 driven wells, arranged on three lines of suction mains as shown in fig. 59. The east and west expanse of the two chief lines of wells is about 1,500 feet. The wells of this station are of two different types, shallow wells of depth of about 24 feet and deeper wells, extending below an impervious bed to depths of from 60 to 112 feet. These latter wells have an artesian head of 3 or 4 feet, and when the pumping plant is idle the water from the deep wells flows into the suction main and into the shallow wells, whence the water escapes into the sands and gravels of the upper zone of flow. An attempt was made on June 24 to measure the rate of motion of the ground water at station 2, situated 17 feet west of the chief discharge pipe and 300 feet north of the intersection of the main suction pipes from the driven wells, as shown in fig. 59. The attempted measurement was a failure, it not being

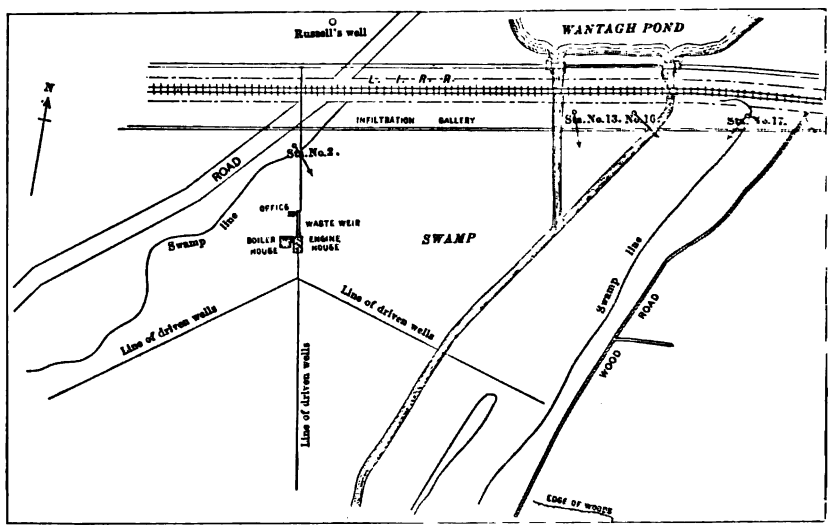



FIG. 59.—Map showing location of stations 2, 13, 16, and 17 near Wantagh pumping station and Wantagh Pond. The arrows indicate the direction of flow of ground water. The flow at station 2 was observed while pumps were drawing water from the three lines of driven wells.

known at that time that the discharge from the numerous artesian wells was entering the surface layers of gravels and hence interfering with the normal flow in these gravels. The ground water at station 2 was, on account of this situation, either entirely stationary or moving slightly toward the north. On August 21 well A of station 2 was charged at 6 p. m., or after eleven hours of continuous pumping from the driven wells. The velocity of the ground waters observed was at the rate of 6 feet a day in a direction 40° east of south. As this station is distant only 300 feet from the lines of driven wells, it is evident that the withdrawal of 4,366,000 gallons, or 582,000 cubic feet, per twenty-four hours has not an excessive influence on the normal rate of motion of the ground waters. The results at Wantagh compare very well with

the results at Agawam, and indicate that the driven-well plants have not exhausted the possibilities of ground-water developments.

## CONCLUSION.

The very evident conclusion from observations on Long Island is that large amounts of ground water can still be obtained along the south shore of the island, especially if deep wells of large diameter can be successfully bored. The writer has already called attention to the possibility of constructing 12-inch wells of the California or "stovepipe" type in the unconsolidated material which extends from the surface to considerable depths on Long Island. Such wells, several hundred feet in depth, with perforations opposite the best water-bearing material, would utilize a large part of the underflow which now escapes to the sea. The practicability and success of such wells in this locality seems very probable, but the only way to arrive at an entirely satisfactory conclusion is to actually construct a test well.

# CHAPTER VII.

## THE SPECIFIC CAPACITY OF WELLS.

### GENERAL PRINCIPLES.

The amount of water discharged or obtained from a tubular well is a quantity which is as rigidly dependent upon certain definite and measurable factors as the total horsepower of a steam engine is dependent upon the elements in its design and the pressure of steam furnished to the engine. Very few persons realize, however, the closeness and intimacy of the dependence of the yield of a well upon the various causes represented by the character of the water-bearing material in which it is constructed and the size and shape of the well itself. In fact, the available published data containing the results of actual tests of the capacity of wells are usually incomplete in some important particular, so that no laws or general principles are discernible even where they exist. With every well, no matter what its size or method of construction, there can be associated a perfectly definite quantity which expresses the capacity of that well to furnish water. In order to add definiteness to well construction and well data, such a quantity should be applied to every well whose capacity is measured. It can conveniently be designated by the term "specific capacity." By "specific capacity" of a well is meant the amount of water furnished under a standard unit head, or the amount of water furnished under unit lowering of the surface of the water in the well by pumping. This number can be made definite by agreeing upon the unit of measure of quantity of water and on the unit in which the head is to be measured. If the unit of yield be the "second-foot," or cubic foot of water per second of time, and if the hydraulic head be measured in feet of water, then the specific capacity of any well is found by dividing the number of second-feet by the hydraulic head. For example, if an artesian well flows 2 second-feet, and if the static head in the well when the water is not permitted to flow is equivalent to a head of 20 feet of water, then the specific capacity of the well is 2 divided by 20, or 0.1 second-foot. We describe the specific capacity by saying that the specific capacity of the well is 0.1 second-foot. Likewise, if we desire to speak of the specific capacity of a common tubular well which is not artesian in character, we can proceed in a similar way. For example, if the well yields 2 second-feet when the water in the well is lowered 20

feet below its normal position, the specific capacity is found by dividing 2 second-feet by 20, giving a specific capacity of 0.1 second-foot.

For the purpose of expressing the capacity of wells, the second-foot will be found to be a large unit of capacity, so that it will often be convenient to express the yield in gallons per minute, rather than in second-feet. One second-foot is equivalent to about 450 gallons per minute, so that the specific capacity of the wells above given might be stated as "45 gallons per minute." Another convenient unit of measure for the capacity of the well is the miner's inch, the California miner's inch being one-fiftieth of a second-foot, and hence of a very convenient size for the measurement of well capacity. However, the different values of the miner's inch prevalent in various sections of the country make this unit of measure undesirable for general use.

The importance of accurate knowledge of the specific capacity of the wells of a locality can not be overestimated. To the owner of a well it is very important that he know whether or not his well is better or poorer than neighboring wells, and whether the difference is due to a diversity in pumping machinery or to a difference in the well itself. To one who contemplates the construction of a well it is of the first importance that he know how much water he may expect to obtain, and in what manner it can best be obtained. In spite of striking examples of irregularity, it is usually true that the same water-bearing material is very uniform in a given locality, and by properly designing a well one should be able to estimate in advance of construction the capacity of a well with a very small per cent of error. However, tests on existing wells and all data concerning them will have to be obtained and recorded with much greater accuracy and completeness than heretofore if this desirable result is to be realized.

It does not count against the above statements concerning the ability to determine in advance the probable yield of a well, to find that neighboring wells, similarly constructed, yield very different amounts of water, or that water can not be obtained a short distance from a good well. Such a discovery always causes considerable comment, while the numerous cases in which ground water is found at very uniform depths and in nearly identical material call forth no comment whatever.

The amount of water yielded by a common open well or by a non-flowing tubular well is dependent first of all upon the degree of fineness of the material in the various strata from which the water is obtained. The size of the soil grains not only controls the rate at which water can be transmitted to the well under a given head, but it also determines the proportion of contained water which the soil will freely part with. The fine-grained soils retain a considerable proportion of the water of saturation as capillary water even after free means of drainage are established, so that fine-grained material will not only deliver water

slowly, but will furnish only a small total amount. Some quicksand is so fine that the water can be pulled away from the fine grains with the greatest difficulty, while silt with a diameter of grain of about one one-thousandth of an inch (not at all an unusual size) will part with its water very slowly even when it is placed on a piece of blotting paper.

The above factor in the specific capacity of the well can be expressed by means of the transmission constant, $k$, of the material furnishing the water. Other things being equal, the yield of the well will vary directly with the transmission constant.

Another cause effecting the yield of the well is the thickness of the water-bearing stratum. If the transmission constants of all water-bearing strata are the same, the amount of water available is directly dependent upon the thickness of strata penetrated, provided, of course, that only such material is counted as is in contact with a suitable well screen or strainer.

An important factor in determining the yield of a well is the diameter of the well. By the diameter is meant the diameter of the well where it penetrates the water-bearing stratum. The diameter of the well is a factor which determines the rate at which the water must move in the water-bearing material as it enters the well. A well having a large casing will permit a given amount of water to enter under a low velocity, and hence with little friction in the pores of the water-bearing medium. The dependence of the yield upon the diameter of the well is not expressible in a very simple way. In fine material, the dependence of the yield upon the diameter of the well is very much less than is commonly supposed. Only in material that is very coarse is it usual that any great advantage is obtained by using casing as large as 16 to 24 inches in diameter.

The friction of the water as it flows upward in the casing of a well, a factor which is often very large in the case of an artesian well, is usually small or negligible in common tubular wells from which the water is pumped with a suction pipe much smaller than the diameter of the well itself. This statement must not be understood to imply that the amount of water discharged by the pump is not influenced by the size of the suction and discharge pipes. What is meant is that, with a given lowering of the water in the well the yield of water will not be dependent upon the friction in the casing to the upward-moving water, while of course the amount of power applied to the pump will be greatly influenced by the size of the suction and discharge pipe and upon the manner in which these pipes are installed.

Finally, the specific capacity, if the well be not too shallow, varies directly as the distance the surface of the water in the well is lowered by pumping. Thus, if the water in a well is lowered 2 feet below the natural level by pumping from it at the rate of 20 gallons a minute, the same well may be expected to yield approximately 40 gallons a

minute if the water is lowered 4 feet below the natural level. For shallow wells the yield will not increase in this direct ratio, but will be considerably less on account of the decrease in percolating surface due to the lowering of the water plane in the neighborhood of the well. Besides the advantages just mentioned, tubular wells, owing to their greater depth, are much more likely to strike a vein of coarse material, a small stratum of which may be expected to furnish much more water than a considerable depth of fine material. This accounts for the well-known superiority of deep tubular wells over common dug wells.

If a well be cased through the water-bearing medium, the character of the screen or perforations in the casing will of course influence the yield of the well. If a screen is clogged, or if the perforations are not ample, the capacity of the well will be cut down because of this imperfect casing.

All of the factors named above influence the yield of a flowing artesian well, except that in place of the distance the water is lowered by pumping we must substitute the static head at the point of discharge of the flowing water. By the static head is meant the pressure when the well is closed at the point at which the flow is measured. This static head is conveniently expressed in terms of feet of water. For example, instead of giving the static head in pounds per square inch we can state it in feet of water. The flow of water from the porous medium into the well will vary directly as the static head, but the total yield of the well will not vary in this simple way on account of the frictional resistance which the water suffers in flowing through the casing and drill hole of the well. This last component of the specific capacity while usually small in a well that is pumped is often of the very first importance in the case of a flowing well. To the friction in the casing and discharge pipe should be added the influence of all turns and bends and reductions in size and the like. This factor is often a very large one in the determination of the amount of water yielded by an artesian well. The resistance due to friction increases very greatly with a decrease in the size of pipe and also with an increase in the length of the pipe, and is materially influenced by the curves and variations in size of the pipe and by the rivets and joints in the well casing or discharge pipes. The friction in pipes does not vary directly with the hydraulic head, but approximately as the square root of the head at which the flow takes place.

As stated before, complete data concerning tubular wells are very difficult to obtain. Complete data concerning an artesian well should consist of the following: First, exact dimensions of all casing and sizes of the bore hole, including, of course, total depth; second, the static head of the well measured at a point a known distance above the surface of the ground; third, an accurate measurement of the amount of

water yielded by the well when freely flowing under the measured static head; fourth, the thickness of the various water-bearing strata furnishing water to the well. The data for common tubular wells should include the following facts: First, the diameter of the well casing; second, the depth to water; third, the depth of the well; fourth, the length of screen or perforations in the well; fifth, the character of the perforations; sixth, the amount of water obtained from the well under continuous pumping; seventh, the amount that the water in the well is lowered below its normal level during such pumping. From these facts the specific capacity of the well can be computed and many important facts can be determined. Additional data of considerable importance would be the following: Eighth, the distance the water is raised by the pumps; ninth, the cost or expense of pumping.

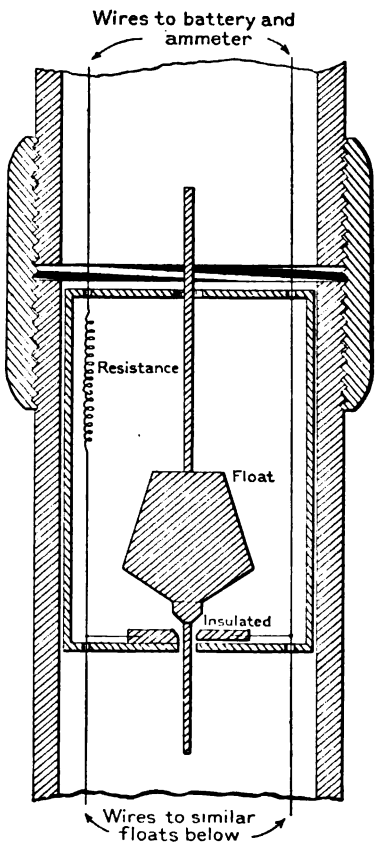



FIG. 69.—Apparatus for measuring the rate of rise of water in wells. A number of floats, as shown in the figure, are placed a foot apart in a 1-inch brass tube. The rising water in the well raises the several floats in turn and registers the time on an ammeter above.

Complete estimate of the specific capacity of a tubular well can be made if the following data can be obtained: First, the amount that the water in the well is lowered below the undisturbed water plane; second, the rate at which the water rises in the well after pumping ceases; third, diameter of casing and of suction pipe. The determination of the rate at which the water rises in the well casing requires some special appliances, a stop watch being usually a necessity. Additional apparatus for this purpose has been constructed and is shown in fig. 60. The apparatus consists of a brass tube 1 inch in diameter containing some small floats placed at distances of about 1 foot apart. The apparatus is lowered into the well until its lower end reaches the level of water in the well when it is being pumped. When pumping ceases water in the well rises and raises in succession each float from its seat, which in turn is indicated to the observer by the deflection of a needle that is controlled by electric circuit running to the several floats. By use of a stop watch the rate at which water rises in the well can be determined. The manner of using the apparatus will be easily understood from the diagram.

The rate of rise of the water surface in the well after it has been depressed by pumping should furnish a very smooth and regular curve when plotted on cross-section paper. The law of this curve is such that if at the end of a certain period of time (say fifteen minutes) the depression of the water surface in the well is half of the original amount of depression just before pumping ceased, then at the end of twice that period of time (thirty minutes) the depression will be one-fourth of the original amount; at the end of thrice that period of time (forty-five minutes) it will be one-eighth of the original amount, etc. Four curves of rise of water in wells are given in fig. 61. Curves 3 and 4 are from the same well, but during the rise shown by 4 a neighboring well 20 feet distant was being pumped.

The theoretical law of rise of water in a well can also be expressed by a formula, as follows:

$$t = \frac{17.25\,A}{c} \log \frac{h}{H}$$

In this formula A is the area in square feet of the cross section of the well casing, counting out the area of the pump rod, suction pipe, or other obstruction. H is the amount in feet that the surface of the water in the well was depressed below its natural level just before pumping stopped; $c$ is the specific capacity of the well expressed in gallons per minute; $h$ is the amount in feet of depression of the water surface below the natural level at any time $t$ (in minutes) after pumping ceased. By taking two corresponding values of $h$ and $t$ from the curve of rise of water surface, the specific capacity of the well ($c$) can easily be computed from the formula

$$c = 17.25 \frac{A}{t} \log \frac{h}{H} \text{ gallons per minute.}$$

Examples of use of this formula will be given below (p. 93). The logarithm indicated by "log" is the common or Briggs logarithm.

The following reports of tests on small wells used for irrigation illustrate the importance of accurate tests of this kind and indicate the sort of information that it is desirable to secure. The first test shows a well-constructed plant giving fair service. The second plant shows a well-constructed plant, but indicates not only an inefficient style of pump, but showed an expensive waste of gasoline through a hidden leak in the feed pipe.

## TESTS.

### TEST I. ON WELL AND GASOLINE PUMPING PLANT OF D. H. LOGAN, GARDEN, KANS.

This plant is located on the northeast corner of sec. 13, T. 24 S., R. 33 W., and is in the northwest corner of the city of Garden. The outfit consists of a 6-horsepower Fairbanks, Morse & Co., horizontal

gasoline engine connected by a belt to a No. 3 centrifugal pump. The well is constructed of a 20-inch galvanized-iron casing 32 feet long, perforated 10 feet up from the bottom, inside of which are two 4-inch feeders 28 feet long, perforated their entire length and extending 26 feet below the bottom of the 20-inch casing, making a total depth of 38 feet. The pump has been in operation since April, 1902, and the engine since April, 1903. The water was measured by the use of a fully contracted weir with a length of crest of 0.66 feet.

The engine was started at 9 o'clock, and the weir was ready for water at about 10.30. The water was turned on weir and the head read until it became constant at 1 p. m., then height was read every five minutes until 2.30 p. m. In order to determine the expense of pumping, all of the gasoline in the reservoir was used, then 1 gallon was poured in and the length of the run noted to be one hour and thirty-two minutes, or two-thirds gallon per hour. As the engine is 6 horsepower, this equals 0.111 gallon, or 0.445 quart of gasoline per horsepower hour.

The average corrected head on the weir was found to be 0.440 feet. Using the weir formula

$$q = c^{2/3} \sqrt{2g}\, b\, H^{3/2}$$

where $b$=.66, and $c$=.592, the discharge is found to be

$$q = 9.6045 \text{ second-feet.}$$
$$= 272 \text{ gallons per minute.}$$
$$= 16{,}320 \text{ gallons per hour.}$$

| | Feet. |
|---|---|
| Average depth to water while pumping | 18.6 |
| Elevation of well platform, 2,835.26 feet. | |
| Normal depth to water | 11.75 |
| Amount lowered by pumping | 6.85 |
| Distance water was raised above platform | 3.5 |
| Total distance water was raised | 22.1 |

Cost of pumping was therefore 0.9 cent per 1,000 gallons, or 0.0406 cent per 1,000 foot-gallons (1,000 gallons raised 1 foot).

The engine ran at a rate of 350 revolutions per minute, exploding 143 times per minute. The diameter of engine pulley is 16 inches and of pump pulley 10 inches. This gives a speed somewhat less than 560 revolutions per minute to the pump.

### SEEPAGE AND EVAPORATION.

The size of the pond was 40 by 60 feet, mostly covered with a green scum, which would decrease evaporation. As to seepage, the pond falls 8 inches in twelve hours at night. The pond being 2,400 square feet in area, the observed seepage represents a loss of 16.68 gallons per minute, which should be added to the capacity of pump and well, but not to the effective capacity for Mr. Logan.

There is a windmill 20 feet north of the well pumped by the engine, a 12-foot aermotor connected to a 10-inch pump of 12-inch stroke. After the weir measurements were completed the windmill was thrown into gear. There was a brisk wind from the south and the pump threw a good quantity of water, but no appreciable lowering of the water was detected in the well being tested 20 feet away. The rise of the water in the well was obtained twice.

Below are the two sets of observations:

| First trial; windmill not running. | | | Second trial; windmill running. | | |
|---|---|---|---|---|---|
| Minutes. | Seconds. | Stopped pumping. | Minutes. | Seconds. | Stopped pumping. |
| 0 | 55 | 18.60 | 24 | 30 | ..... |
| 1 | 05 | 16.05 | ..... | 35 | 18.0 |
| 1 | 20 | 14.55 | ..... | 45 | 16.5 |
| 1 | 37 | 12.95 | ..... | 48 | 14.35 |
| 1 | 55 | 12.50 | 25 | 10 | 13.10 |
| 2 | 8 | 12.35 | ..... | 26 | 12.90 |
| ..... | 22 | 12.35 | ..... | 38 | 12.55 |
| ..... | 33 | 12.25 | ..... | 48 | 12.55 |
| ..... | 48 | 12.15 | 26 | 00 | 12.45 |
| | | | ..... | 23 | 12.25 |
| | | | ..... | 47 | 12.25 |
| | | | ..... | 58 | 12.25 |
| | | | 27 | 15 | 12.25 |
| | | | ..... | 30 | 12.25 |

The curves showing the rate of rise of water in the Logan well after pumping ceased are given by curves 3 and 4 in fig. 61. The curve 4 is the one which was produced when the windmill was pumping from a well 20 feet from the one for which the curve is drawn. The comparison of this curve with curve 3, which was produced when the neighboring well was not used, is very interesting, showing as it does a less rapid rise when the neighboring well was in use. To find the specific capacity for the Logan well from these curves we must substitute the values of the various constants in the formula

$$c=17.25\,\frac{A}{t}\,\log.\,\frac{H}{h}\text{ gallons per minute.}$$

The value of A, the area of cross section of the well casing, is 2.17 square feet, and of H, the amount the water is lowered by the pump, 6.85 feet. The amount of depression $h$ of the water level below the

natural level at any time can then be selected from the curve and the specific capacity readily computed. If $t$ be taken to be forty seconds, or two-thirds minute, $h$ will be found from the curve to equal 6.85—5.5=1.35 feet, hence

$$c=17.25\times\frac{3}{2}\times 2.17\times\log\left(\frac{6.85}{1.35}\right)\text{ gallons per minute.}$$
$$=39.5\text{ gallons per minute.}$$

The yield of the well for the maximum depression, 6.85 feet, must then be

$$6.85\times 39.5=270\text{ gallons per minute.}$$

The curve of rise of water forms one of the best methods of determining the yield of a well. Such curves can readily be obtained.

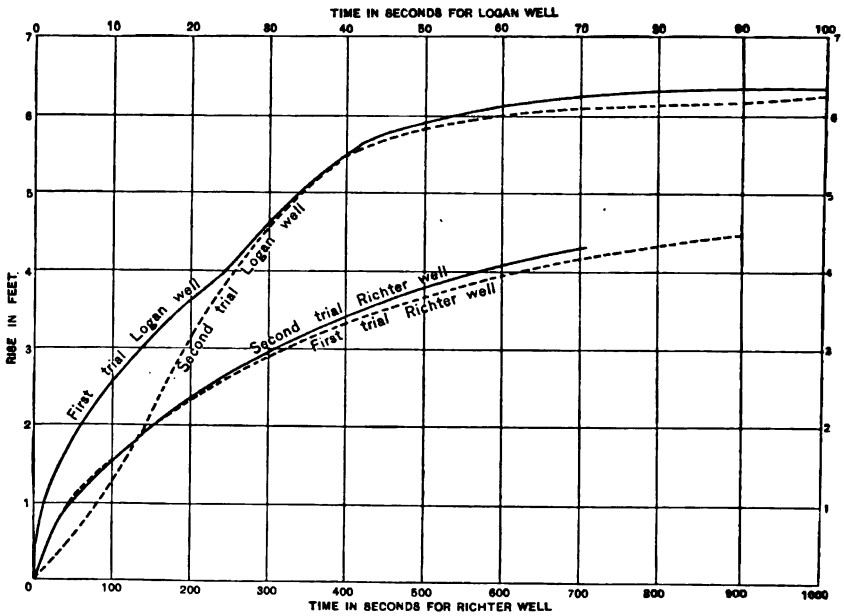



FIG. 61. Curves showing the rate of rise of water in the Richter and Logan wells near Garden, Kans. Curve 1 (dotted), first trial of Richter well; curve 2 (solid), second trial of Richter well; curve 3 (solid), first trial of Logan well; curve 4 (dotted), second trial of Logan well.

Well data should always include measurements of the amount of lowering of the water surface by the pumps, and it is only necessary to continue these measurements after the pumps have stopped to secure sufficient data to estimate the specific capacity and total yield of the well. This avoids the necessity of constructing a weir or other method of measuring the water discharged. The accuracy is sufficient for the purpose for which such data are used.

TEST II. ON WELL AND GASOLINE PUMPING PLANT OWNED BY MINNIE RICHTER, FINNEY COUNTY, KANS.

This plant is located in the northwest corner of the SW. ¼ sec. 14, T. 24 S., R. 33 W. The upper part of this well is cased with part of an old standpipe from the city of Garden. The casing is 10 feet in diameter and extends down 20 feet. In the bottom of this part of the well are placed four 8-inch galvanized-iron feeders, arranged symmetrically about the center. Each feeder is 25 feet long, perforated its entire length, and extends about 2½ feet above the bottom of the large part of the well.

The pump used operates on the principle of a screw propeller of a steamship. It bores the water out and up a square wooden penstock or pump shaft. There are two of these propellers, mounted one above the other on a vertical iron shaft inside the penstock. The top of the iron shaft carries the belt pulley and has a shoulder bearing which takes the thrust of the pump. This pump (called the Menge) is made in New Orleans. The pump is run by a 10-horsepower Otto gasoline engine, which runs at a speed of 300 revolutions per minute. The circumference of the drive pulley is 5.25 feet and of the driven pulley 2.65 feet, making the pump run at 595 revolutions per minute. The screws are under water when the pump is not in operation. A small pond was constructed at the end of the discharge trough, and a fully contracted rectangular weir of length of crest of 1.2 feet was used to measure the discharge. The measurements for head were taken 6 feet away from the weir, and boards were interposed between the discharge trough and weir to cut down the velocity which might tend to give erroneous results. The average corrected head on the weir was 0.371 feet. Using the weir formula

$$q = c\tfrac{2}{3}\sqrt{2g}\, b\, H^{\frac{3}{2}},$$

and, taking $c$ from Merriman's tables as 0.603,

$$q = 0.876 \text{ second-feet},$$
$$= 394 \text{ gallons per minute},$$

or using Francis formula

$$q = 3.33\,(b - 0.2\,H)\,H^{\frac{3}{2}},$$
$$= 314 \text{ gallons per minute}.$$

Using a small Price acoustic water meter in the discharge trough, by measuring the velocity at different places, and also by integrating, the discharge was found to be 0.76 second-feet = 342 gallons per minute. By putting chips in the discharge trough and catching the time with a stop watch, the surface velocity was found to be 1.565 feet per second. This multiplied by 0.8 gives an average velocity of 1.25 feet per second and a discharge of 0.884 second-feet = 397 gallons per minute.

An attempt was made to determine the amount of gasoline used. The reservoir was filled full and the engine run for one hour and thirty-six minutes, or 1.6 hours. All the gasoline we had, 9¼ quarts, did not

then fill the tank. This was at noon, July 6. On the morning of July 7, 9½ quarts were required to completely fill the reservoir, a total of 18¾ quarts or 37½ pints for the run of 1.6 hours for a 10-horsepower engine. The makers claim that their engines use 1 pint per horsepower hour. This would require in this case 16 pints, or less than half of what was actually measured, if the engine developed its full horsepower. A leak in the tank or feed pipe is clearly indicated. This fact, while being of value to the owner of the plant, shows the record to be worthless as far as comparative cost of pumping is concerned.

Two observations of the rising curve were obtained which agree very well. The lower part of the curve is not accurate because the water in the penstock drops back into the well when pumping ceases.

| | Feet. |
|---|---|
| The elevation of the ground at well is | 2,846.0 |
| Average elevation of water in well | 2,836.6 |
| Average elevation of water in well when pumping | 2,831.5 |
| Elevation of discharge from penstock | 2,847.0 |
| Lift | 15.5 |
| Average amount water is lowered | 5.3 |

Number of explosions of engine, 126.5 per minute.

The curves of rise for this well were obtained on two different occasions, and are shown as curves 1 and 2 in fig. 61. They agree very well. To find the specific capacity of the well from the curve, we note the following values of the constants in the formula for specific capacity:

$$c = 17.25 \frac{A}{t} \log \frac{H}{h} \text{ gallons per minute.}$$

The area, A, of cross section of the well casing is 76.79 square feet. The amount, H, that the water is lowered by the pump is 5.3 feet. The amount of depression, $h$, of the water surface below the natural level at any time can be selected from the curve. From the curve, at the close of ten minutes, $h$ equals $5.3 - 4 = 1.3$ foot. Hence the specific capacity,

$$c = 17.25 \times \frac{76.79}{10} \log \frac{5.3}{1.3} = 81 \text{ gallons per minute.}$$

Multiplying by 5.1, the head under which pumping took place, the total yield of the well is $81 \times 5.3 = 429.3$ gallons a minute.

The above determination of the specific capacity is inaccurate, since the first portion of the rising curve does not show the true rate of rise of water in the well. The penstock of the propeller pump holds 37.7 cubic feet of water, which immediately returns to the well when the pump is stopped. This amount of water is sufficient itself to raise the level in the well by 0.465 foot. For this reason only that portion of the rising curve should be used which is uninfluenced by the return-

ing water from the penstock. Thus, if we use that part of the curve from $t=100$ seconds to $t=600$ seconds, we will eliminate the inaccurate portion. By this modification the data are changed to $H=3.75$ feet; $h=1.30$ feet; $t=\frac{5}{6}$ minute. Computing the specific capacity on this basis we obtain $c=73$ gallons per minute. This multiplied by 5.3 gives the total estimated yield 388 gallons per minute, which checks more nearly with the 394 gallons per minute previously obtained.

The area of the surface of the strainers and the bottom of the well is 266.5 square feet. The above specific capacity divided by 266.5 gives .341 gallon per minute as the specific capacity per square foot of percolating surface.

The engine ran at a speed of 300 revolutions per minute and exploded 125 times per minute. This would indicate that it was working at about 83 per cent of its rated capacity. Assuming that such was the case, and that it would then use 83 per cent of the fuel necessary to run it at is full rated power (10 horsepower), we have 8.3 pints as the probable amount of gasoline used per hour by the engine during the test. This, at 20 cents per gallon, would make a cost of 21 cents per hour. This assumption makes the cost of water 0.89 cent per 1,000 gallons, $2.90 per acre-foot, and one-seventeenth cent per 1,000 foot-gallons.

# CHAPTER VIII.

## THE CALIFORNIA OR "STOVEPIPE" METHOD OF WELL CONSTRUCTION FOR WATER SUPPLY.

### MODE OF CONSTRUCTION.

The peculiar conditions of water supply existing in southern California have led to the development of a special type of well, which the writer believes to be admirably adapted to conditions found in many places in the various parts of the United States. It is hoped that the following account will call the attention of those interested in recovering ground water in large quantities to the many points of excellence of the California type of well and method of well construction.

The valleys of southern California are filled with deposits of mountain débris, gravels, sands, bowlders, clays, etc., to a depth of several hundred feet, into which a considerable part of the run-off of the mountains sink. The development of irrigation upon these valleys soon became so extensive that it was necessary to supplement more and more the perennial flow of the canyon streams by ground water drawn from wells in the gravels. This necessity was greatly accentuated by a series of dry years, so that ground waters became a most valuable source of auxiliary supply for irrigation in the important citrus areas in southern California. The type of well that came to the front and developed under these circumstances is locally known as the "stovepipe" well. It seems to suit admirably the conditions prevailing in southern California. In developing water supply for irrigation the item of cost is of course much more strongly emphasized than in developments for municipal supply. The drillers of wells in California were confronted not only with a material which is almost everywhere full of bowlders and like kinds of mountain débris, but also with a high cost of labor and of well casings. It was undoubtedly these difficulties that led to the very general adoption in California of the stovepipe well.

The wells are put down in the gravel and bowlder mountain outwash, or other unconsolidated material, to any of the depths common in other localities. One string of casing, in a favorable location, has been put down over 1,300 feet. The usual sizes of casings are 8, 10, 12, 14 inches, and even larger. A common size is 12 inches. The well casing consists of: First, a riveted sheet steel "starter" 15 to

*A.* TWELVE-INCH STOVEPIPE STARTER.

*B.* TWO LENGTHS OF STOVEPIPE CASING.

25 feet long, made of two or three thicknesses of No. 10 sheet steel, with a forged steel shoe at the lower end. Pl. XII, *A*, shows a starter 21 feet long, made of double No. 10 sheet steel, with a ¾- by 8- by 12-inch steel shoe riveted on the bottom. In ground where large bowlders are encountered the starters are made heavier, the shoe is 1 inch thick and 12 inches long, and three-ply instead of two-ply No. 10 sheet steel body is used.

Above the starter, the rest of the well casing consists of two thicknesses of No. 12 sheet steel made into riveted lengths, each 2 feet long. One set of sections is made just enough smaller than the other so that one length will telescope snugly inside of the other. Each outside section overlaps the inside section 1 foot, so that a smooth surface results both outside and inside of the well when the casing is in place, and so that the break in the joints is always opposite the middle of a 2-foot length. It is these short, overlapping sections which are popularly known as "stovepiping." A pile of this casing ready for use is shown in Pl. XIII, *A*, and two lengths are shown on a larger scale in Pl. XII, *B*. The sheets of steel can be taken to the field flat and the riveting done during the process of well construction.

The casing is sunk by large steam machinery of the usual oil-well type, but with certain very important modifications. The well rig shown in Pl. XIII has a derrick with mast 40 feet high. When ready to move, the mast swings backward on hinges with the top resting on upright at the rear end of the rig, as shown in fig. 63. Jackscrews are placed under the sills and the whole machine is raised sufficiently to allow wheels to be placed on two axles bolted to the sills. The photograph reproduced in Pl. XIII also shows a 25-horsepower boiler mounted on separate trucks. The 10-inch sand pump and jars are shown just as they have been pulled out of a 12-inch well.

In ordinary material the "sand pump" or "sand bucket" is relied upon to loosen and remove the material from the inside of the casing. The casing itself is forced down, length by length, by two or more hydraulic jacks, buried in the ground and anchored to two timbers 14 inches square and 16 feet long, planked over and buried in 9 or 10 feet of soil. These jacks press upon the upper sections of the stovepiping by means of a suitable head. In Pl. XIII, *B*, the clevises of the pistons of the hydraulic jacks can be seen hooked over the ears of the well cap. The jacks, whose clevises appear in the cuts, have 8-inch piston and 4½-foot stroke, and a combined pull of about 120 tons. The driller, who stands at the front of the rig, has complete control of the engine, hydraulic pump, and valves by which pistons are moved up or down, and also of the lever which controls two clutches which cause tools to work up and down or to be hoisted. The hydraulic pump is mounted upon the main frame of derrick, as shown in Pl. XIV, *B*. The one shown is a Marsh pump with a steam cylinder of 8-inch

diameter, and water cylinder of $1\frac{5}{8}$-inch diameter with 12-inch stroke. It is coupled to the jacks with extra strong $\frac{3}{4}$-inch hydraulic pipe and fittings. Smaller rigs use a pump with $6\frac{1}{8}$-inch steam by $1\frac{1}{8}$-inch water cylinders, 10-inch stroke, and coupled to jacks with $\frac{1}{2}$-inch pipe. A boiler pressure of 100 pounds puts nearly a limiting stress on the $\frac{1}{2}$-inch pipe and it sometimes breaks.

The sand pumps used are unusually large and heavy. For 12-inch work they will vary in length from 12 to 16 feet, $10\frac{5}{8}$ inches in diameter, and will weigh, with lower half of jars, from 1,100 to 1,400 pounds.

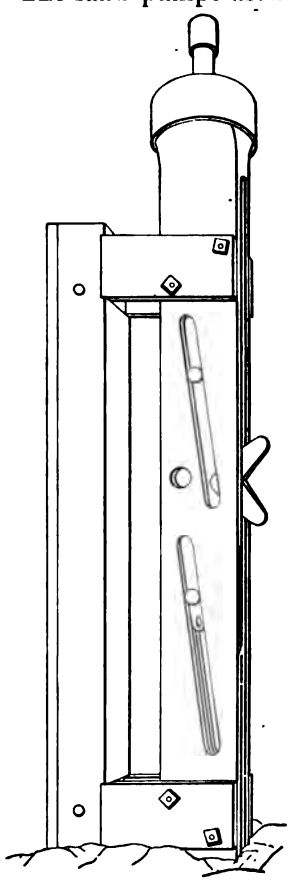


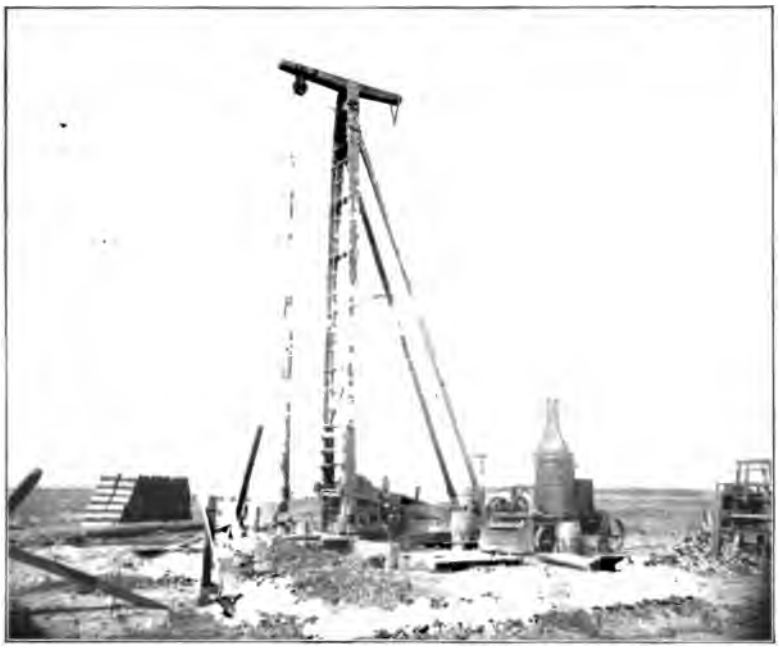
FIG. 62.—Roller type of perforators for slitting stovepipe wells. This perforator was used for cutting 60 feet of screen in the wells shown in Pl. XV.

After the well has been forced to the required depth, a cutting knife is lowered into the well and vertical slits are cut in the casing where desired. A record of material encountered in digging the well is kept, and the perforations are made opposite such water-bearing strata as may be most advantageously drawn upon. A well 500 feet deep may possess 400 feet or more of screen if circumstances justify it.

Pl. XIV, *A* shows the perforator for slitting stovepipe casing. It is handled with a 3-inch standard pipe with $\frac{3}{4}$-inch standard pipe on the inside. The perforator is shown in cutting position with knife extended. In going down or in coming out of the well the weight of $\frac{3}{4}$-inch line holds point of knife up. When ready to "stick" the $\frac{3}{4}$-inch line is raised. By raising slowly on 2-inch line with hydraulic jacks, cuts are made three-eighths inch to three-fourths inch wide and 6 to 12 inches long, according to the material at that particular depth.

Fig. 62 shows another type of perforating knife. The revolving cutter punches five holes at each revolution of the wheel. This style of perforator is called a "rolling knife." By means of this tool 60 feet of perforations were cut in the well shown in Pl. XV.

A great many different kinds of perforators are in use in California: in fact, the perforator is a favorite hobby of local inventors. The different patterns in use seem to work well. Those shown in the illustrations are very good.



*A*

*B*

CALIFORNIA WELL RIG.

*A*, Side view; *B*, Front view, showing clevises of hydraulic jacks hooked over ears of well gap.

## ADVANTAGES OF "STOVEPIPE" CONSTRUCTION.

The advantages of this method of well construction are quite obvious. For wells in unconsolidated material the California type is undoubtedly the best yet devised. It is believed that wells of this type would be highly successful in the unconsolidated deposits in other localities. The absence of bowlders and very coarse gravels in some deposits may possibly make it more advantageous to use the hydraulic jet instead of the ponderous sand bucket in soft material, but this is the only modification that these conditions seem to suggest.[a]

Among the special advantages in the stovepipe construction may be enumerated the following:

1. The absence of screw joints liable to break and give out.
2. The flush outer surface of the casing without couplings to catch on bowlders or hang in clay.
3. The elastic character of the casing, permitting it to adjust itself in direction and otherwise to dangerous stresses, to obstacles, etc.
4. The absence of screen or perforation in any part of the casing when first put down, permitting the easy use of sand pump and the penetration of quicksand, etc., without loss of well.
5. The cheapness of large-size casings because made of riveted sheet steel.
6. The advantage of short sections, permitting use of hydraulic jacks in forcing casing into the ground.
7. The ability to perforate the casing at any level at pleasure is a decided advantage over other construction. Deep wells with much screen may thus be heavily drawn upon with little loss of suction head.
8. The character of the perforations made by the cutting knife are the best possible for the delivery of water and avoidance of clogging. The large side of the perforation is inward, so that the casing is not likely to clog with silt and débris
9. The large size of casing possible in this system permits a well to be put down in bowlder wash where a common well could not possibly be driven.
10. The uniform pressure exerted by the hydraulic jacks is a great advantage in safety and in convenience and speed over any system that relies upon the driving of the casing by a weight or ram.
11. The cost of construction is kept at a minimum by the limited amount of labor required to man the rig as well as by the good rate of progress possible in what would be considered in many places impossible material to drive in, and by the cheap form of casing.

## COST OF CONSTRUCTION.

An idea of the cost of construction of these wells can best be given by quoting actual prices on some recent construction in California.

[a] A 12-inch stovepipe well was sunk to a depth of 2,800 feet on the Lanoria Mesa, 7 miles northeast of El Paso, Tex. The last 2,000 feet was drilled in dry clay by use of a powerful hydraulic jet.

According to contracts recently let near Los Angeles the cost of 12-inch wells was 50 cents per foot for the first 100 feet and 25 cents additional per foot for each succeeding 50 feet, casing to be furnished free. This makes the cost of a 500-foot well $700 in addition to casing. The usual type of 12-gage, double, stovepipe casing is about $1.05 a foot, with $40 for 12-foot starter with three-fourths by 8-inch steel ring or shoe. The pay of a good driller is $5 a day, of helpers $2.50 a day. The cost of drilling will run higher than that given above in localities where large and numerous bowlders are encountered.

WELL RIGS.

Pls. XIII and XIV, *B*, show a new rig of very excellent type owned by Mr. E. W. Riggle, Los Angeles, Cal. The drillers build their own

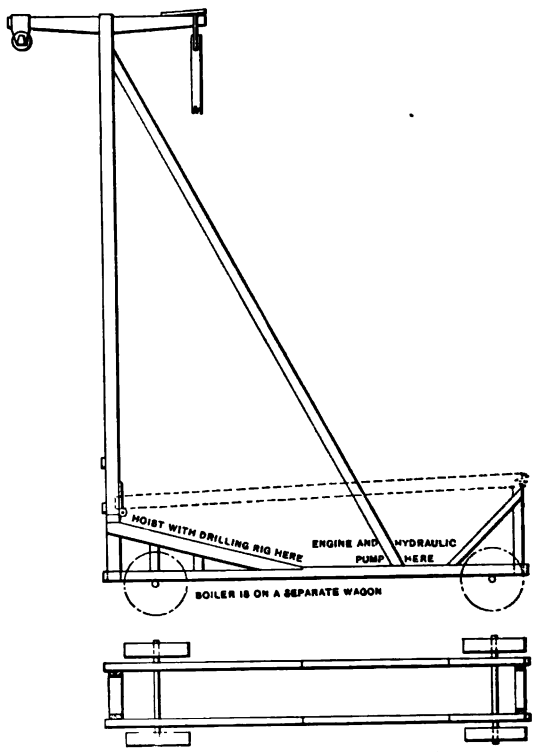
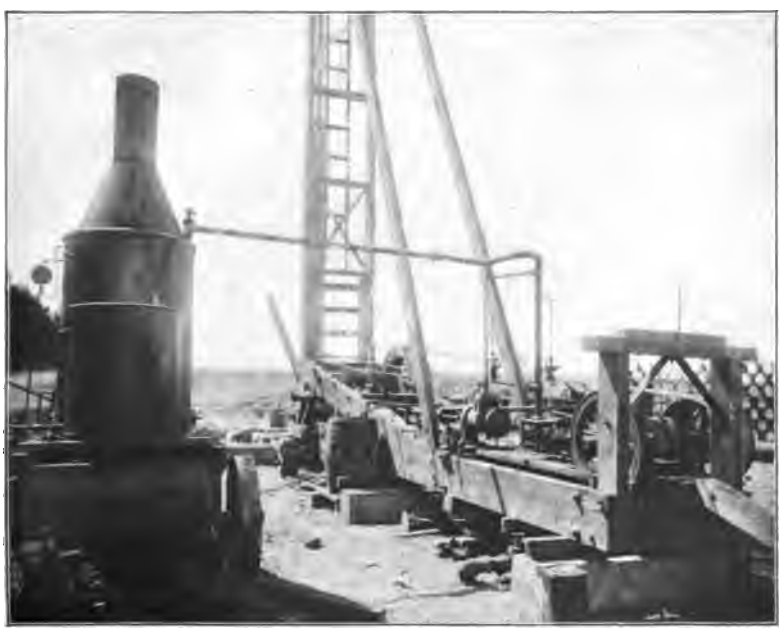



FIG. 63.—Plan and elevation of derrick for California well rig.

rigs according to their own ideas, so that no two rigs are exactly alike—that is, the drillers pick out the castings and working parts and mount them according to ideas that experience has taught them are the best for the wash formations in which they must work. A scale drawing of derrick is shown in fig. 63.

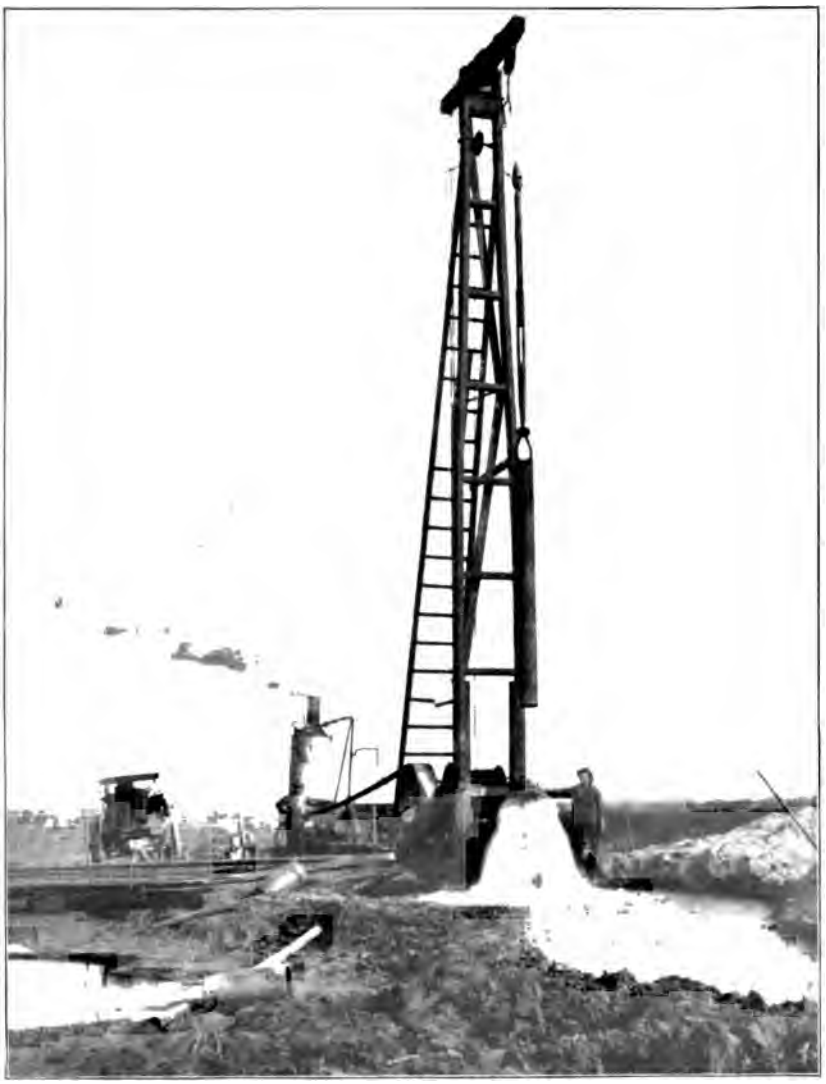
In Pl. XV is shown another excellent California rig owned by Mr. J. B. Proctor, of Compton, Los Angeles County. As it appears

*A.* PERFORATOR FOR SLITTING STOVEPIPE CASING.



*B.* REAR VIEW OF CALIFORNIA WELL RIG.

Showing engine and hydraulic pump.



CALIFORNIA WELL RIG AFTER COMPLETING 12-INCH WELL FLOWING 5,250,000 GALLONS PER TWENTY-FOUR HOURS.

in the cut it has just finished a 12-inch well which flows 404 miner's inches, or about 5,250,000 gallons per twenty-four hours. This well is 848 feet deep and has about 60 feet of perforations. Mr. Proctor used four hydraulic jacks in sinking this well, developing a pressure of 160 to 200 tons.

### YIELD OF WELLS.

It is not very profitable to name individual wells of this type and give their yield, since conditions vary so much from place to place. From the method of construction it must be evident that this type of well is designed to give the very maximum yield, as every water-bearing stratum can be drawn upon. The yield from a number of wells in California of average depth of about 250 feet, pumped by centrifugal pumps, varied from about 25 to 150 miner's inches, or from 300,000 to 2,000,000 gallons a day. These are actual measured yields of water used for irrigation.

Among the very best flowing wells in southern California are those near Long Beach. The Boughton well, the Bixby wells, and the wells of the Sea Side Water Company are 12-inch wells varying from 500 to 700 feet in depth and flowing about 250 miner's inches each, or over 3,000,000 gallons per twenty-four hours. The well shown in Pl. XV is located about 4 miles northeast of Long Beach and its flow is the greatest yet reported.

Among the records of depth are those of 1,360 feet for 10-inch well and 915 feet for 12-inch well. Mr. Proctor has bored a 14-inch well more than 704 feet in depth.

# CHAPTER IX.

## TESTS OF TYPICAL PUMPING PLANTS.

In connection with the general discussion of movement of underground waters it has been thought that a few descriptions of characteristic tests of pumping plants would be of interest and value. With this idea in view a number of typical plants, including several different classes, have been selected from the large number examined and descriptions of the tests prepared.

The Felix Martinez pumping plant is run by electric power and gives a good chance to see what can be done with combination of centrifugal pump and electric motor in the recovery of water for irrigation. The pumping plant of J. A. Smith is of special interest on account of a very low cost of power, due to the use of petroleum gas generated from crude oil. The test of Roualt's pumping plant is of great interest on account of the use of steam engine with wood as fuel. The wood was obtained at a very low price per cord, yet the showing in the cost per acre-foot will not compare with the plants that use gasoline engines with gasoline at 17 cents a gallon. The last pumping plant reported upon, that of the Horaco Ranch Company's well No. 1, is of special interest on account of the all-around excellence and efficiency of the plant. The table that is inclosed summarizes the results at all of the plants and gives items of cost.

### TEST OF PUMPING PLANT OF FELIX MARTINEZ NEAR EL PASO, TEX.

The pumping plant on the ranch of Mr. Felix Martinez, of which a test was made, is located near the main county road east of El Paso, about 3 miles from the court-house. The plant consists of a No. 5 Byron Jackson horizontal-shaft centrifugal pump, run by a General Electric 10-horsepower direct-current motor, type C. E., class 4. The pump is located in a pit, and is connected to a 6-inch well. The well is 68 feet deep, measured from the surface of the ground, and has 10 feet of perforated or slotted galvanized-iron strainer at the bottom. The gravels were reached at a depth of 56 feet, and consisted of fairly large gravel, containing a large quantity of fine sand. The pump is connected with the well by a 5-inch suction pipe and discharges through a vertical and horizontal 5-inch discharge pipe into a rectangular flume. The discharge was measured by integrating with a Price acous-

tic current meter in the rectangular flume. The average depth of water at the cross section of flume where measurements were taken was 0.475 foot. The average width of flume was 0.992 foot, giving an area of 0.470 foot. The mean velocity of the water at the selected

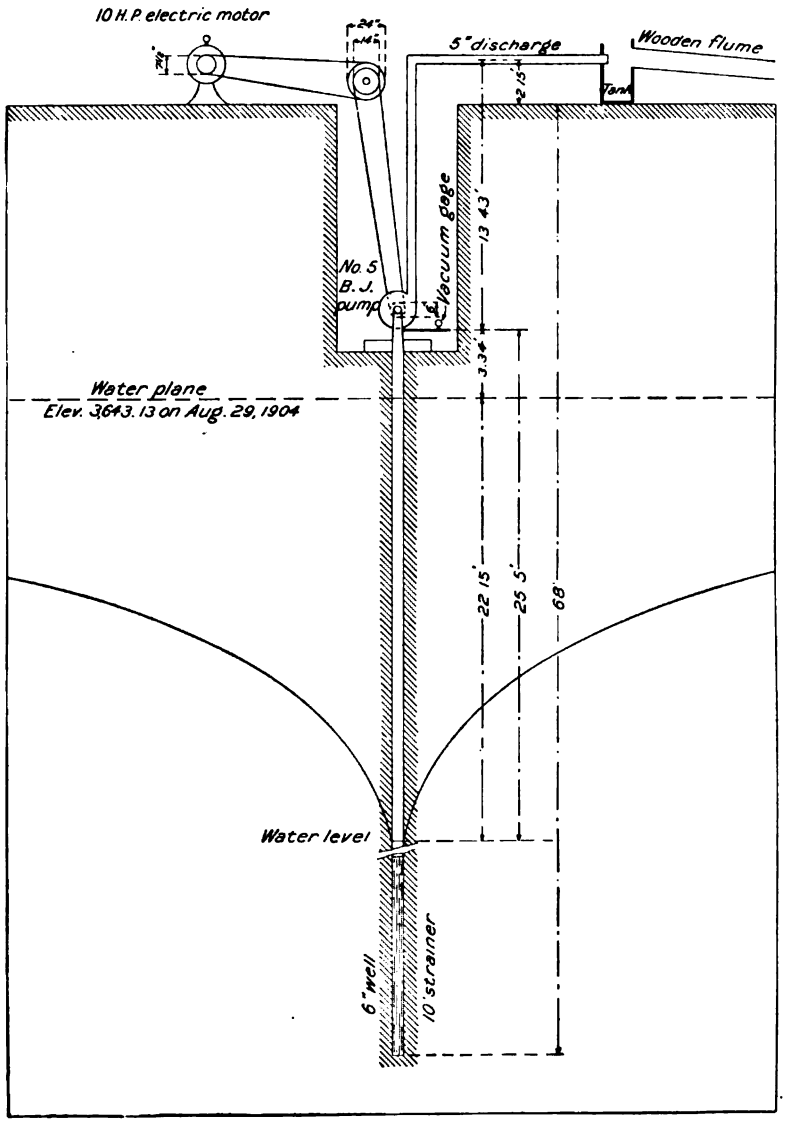



FIG. 64.—Conditions at pumping plant of Felix Martinez near El Paso, Tex.

cross section was 1.78 feet per second, giving total discharge of 0.838 cubic foot per second, or 378 gallons a minute.

The vacuum gage was attached to the goose neck of the centrifugal pump. The vacuum shown after a few minutes pumping was 18

inches, but it gradually fell to 24½ inches at the close of the first half hour, where it remained constant during the next hour. The vacuum, when corrected for altitude, is equivalent to 22.5 inches of mercury, or 25.5 feet of water.

The elevation of the water plane on August 29, 1904, was 3,643.13 feet above sea level. The elevation of tap of vacuum gage was 3,646.47 feet. The elevation of top of discharge pipe was 3,659.90 feet. The total lift is, therefore, 38.93 feet, and the amount the water level in the well was lowered by pumping was 22.16 feet. From this the specific capacity of the well can be determined to be 17.5 gallons a minute. The area of the well strainer is 14.4 square feet, from which we conclude that the specific capacity for each square foot of well screen was 1.21 gallons a minute.

The amount of electric current used during the pumping was determined by means of a Westinghouse watt meter. The current used in one hour's test (average speed of motor, 1,485 revolutions a minute) was 4,950 watts. The speed of the pump was 1,028 revolutions a minute. The pulley dimensions are as follows: Pulley on motor, 7½ inches diameter; driven pulley on countershaft, 24 inches; driving pulley on countershaft, 14 inches; pulley on pump shaft, 6 inches.

The horsepower actually used at the plant is the equivalent of 4,950 watts, or 6.64 horsepower. The power represented by the discharge of 0.838 second-foot of water lifted 38.93 feet, is equivalent to 2,030 foot-pounds per second, which is equal to 3.7 effective horsepower. Comparing the applied horsepower, 6.64, with the effective horsepower, 3.7, the total efficiency of the plant is found to be 55.5 per cent. The duty of the plant can be found by comparing 4,950 watts, the electrical energy consumed in one hour, with 655,200 foot-gallons, the work done by the pump in one hour. The resulting duty is 132,400 foot-gallons of water per kilowatt hour of electric current.

At 5 cents per kilowatt per hour, the cost of power for raising the water at the Martinez plant was one twenty-seventh of a cent for each 1,000 gallons of water raised 1 foot, or $3.43 for each acre-foot of water recovered. The labor cost being very small in an electrically driven plant, the total cost per acre-foot, including depreciation, interest, labor, etc., did not exceed $5.75 per acre-foot.

### TEST OF PUMPING PLANTS OF J. A. SMITH, NEAR EL PASO, TEX.

The pumping plants of J. A. Smith are located 8 miles east of El Paso, Tex., near the right of way of the Southern Pacific Railroad. There are two plants on the same ranch. At the first or older plant there are three wells arranged in a row, 40 feet apart. The pump pit is over the middle well, which is an 8-inch well, 62 feet deep, measured from the top of the ground. Fine sand and quicksand were encountered in sinking this well until a depth of 50 feet was reached, where

coarse gravel containing much fine material was encountered. There was only 12 feet of this coarse gravel. Ten feet of slotted galvanized-iron strainer with hit-and-miss slits was placed at the bottom of this well. The east well is 6 inches in diameter and 73 feet deep. The gravel at this point was found to be 22 feet deep. A 16-foot slotted strainer was used in this well. The west well is also a 6-inch well and is 61 feet deep. The gravel was found to be 11 feet deep, and a 10-foot slotted strainer was used in the well. All of the strainers have $\frac{3}{16}$-inch by $1\frac{1}{2}$-inch slots, or perforations. The horizontal 8-inch suction pipe, which extends from the central well to the east and west wells, is 14 feet below the top of the ground.

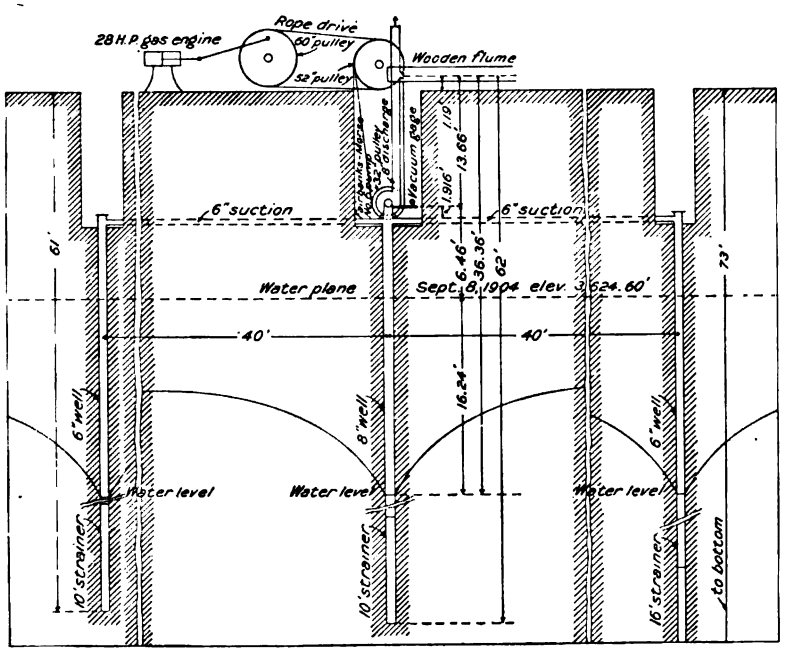



FIG. 65.—Conditions of pumping plant of J. A. Smith, near El Paso, Tex.

The water is pumped by a No. 6 Fairbanks-Morse horizontal-shaft centrifugal pump, connected with rope drive to a 28-horsepower gasoline engine, with crude oil gas generator attached. The fact that the engine is run by producer gas generated from Texas crude petroleum renders this plant of especial interest. The fuel cost relative to the amount of water recovered is the lowest that the writer has recorded for a small plant. The crude oil gas generator has been in operation several months, running continuously day and night, except for a cleaning each week or two. When the generator is kept clean there is little trouble from carbon passing from the generator into the cylinder of the engine and cutting out the cylinder and packing. The plant must be pronounced a decided success, as the further account to be given

will show. The speed of the engine was 159, and of the pump 544 revolutions a minute.

The discharge was measured by integrating with a Price acoustic current meter in a rectangular flume. The average depth of the water at the selected cross section was 0.53 foot, and the average width was 1.87 feet, giving an effective cross section of 0.992 square foot. The average velocity of the water at this cross section was found to be 2.085 feet per second, giving a discharge of 2.075 second-feet or 934 gallons a minute. This measurement of discharge was made after three months of continuous pumping day and night. The elevation of the vacuum-gage tap was 3,631.06, and it was located 1.917 feet above the top of horizontal suction pipe. The elevation of the water plane on September 8, 1904, was 3,624.60, and the elevation of the middle of the 8-inch opening in the tee in the side of vertical discharge pipe, from which the water enters a horizontal wooden flume, was 3,645.05. The vacuum read 22 inches, or 20 inches of mercury when corrected for altitude, which is equivalent to 22.7 feet of water. The total lift is therefore 36.7 feet. The water is lowered in the wells 16.24 feet by pumping, which gives a specific capacity for the three wells of 57.4 gallons a minute. The total area of surface of the strainers in all of the wells is 56.7 square feet, from which we can deduce a specific capacity of 1.01 gallons a minute for each square foot of strainer.

Several accurate tests of the amount of fuel consumed at this plant have been made. One test was made by the manufacturers of the gas generator, and, consequently, the consumption of crude oil appears at a minimum in this test. This test lasted seventy-four hours and fifteen minutes. The amount of crude oil consumed was 241 gallons, or 3.24 gallons per hour. At 3 cents a gallon this makes the cost for oil $2.34 per day of twenty-four hours. The cost for each 1,000 gallons of water recovered was therefore 1¾ mills, or ten fifty-sevenths of a cent. This is at the rate of 57 cents per acre-foot of water. The lift being 37 feet, this makes the cost of 1,000 gallons lifted 1 foot (1,000 "foot-gallons") one two hundred and tenth of a cent.

Another experimental test of the plant was made when the engine was in charge of the regular help employed on the ranch. No effort was made to save oil or make a record, everything being managed exactly as it was during several months of pumping for irrigation. The test was for forty and one-half hours, extending over four consecutive days of about ten working hours each. The amount of crude oil used was 163.5 gallons, or 97 gallons per twenty-four hours, or 4.03 gallons per hour. This represents, therefore, the actual rate at which oil was consumed during the irrigation season. The cost is $2.90 per twenty-four hours, or 12 cents per hour. The cost of fuel for each 1,000 gallons of water delivered was ten forty-sixths of a cent.

and the cost of 1,000 foot-gallons was one one hundred and seventy-first of a cent.

The cost of the water at the same plant, when pumped with gasoline, was also determined. A test of eleven hours' run with same engine, using gasoline instead of crude oil gas, consumed 40 gallons of gasoline, or 3.64 gallons per hour. At 14 cents a gallon, the hourly cost for gasoline was $0.51, which makes the cost of each 1,000 gallons of water pumped $0.0092. The cost per 1,000 foot-gallons was $0.000236, or one forty-second of a cent.

The above estimates do not represent, of course, the total cost of pumping, as no items have been included to cover interest, depreciation, labor, etc.

The 926 gallons a minute furnished by the above plant amounts to a little over 2 second-feet, or 4 acre-feet per twenty-four hours. The cost of fuel per acre-foot of water was, therefore, 73 cents when using crude oil, and $2.99 an acre-foot when using gasoline at 14 cents a gallon.

### TEST OF ROUALT'S PUMPING PLANT NEAR LAS CRUCES, N. MEX.

A test was made at the pumping plant of Theodore Roualt, located on a ranch about 3 miles northwest of Las Cruces, N. Mex. Water is obtained from a 10-inch well, 48 feet deep, containing 10 feet of 9¾-inch slotted galvanized-iron strainer. Water is recovered by a No. 3 Van Wie vertical-shaft centrifugal pump, driven by a 10-horsepower Nagle steam engine, on 18-horsepower horizontal wood-burning boiler. The engine is directly belted to pump shaft by means of 30-inch driving and 12-inch driven pulley. The water is discharged through an 8-inch vertical discharge pipe into a rectangular flume.

The speed of engine was 205 revolutions per minute, and that of the pump was 525. The steam pressure varied between 81 and 83 pounds. The distance from vacuum-gage tap to the water plane was 3.64 feet. The distance of vacuum-gage tap to top of bottom plank of flume was 7.96 feet, and from tap to top of water jet the distance was 8.66 feet.

The vacuum gage read 24.25 inches, which is equivalent, when corrected for altitude, to 22.25 inches of mercury, or 25.5 feet of water, making the total lift 34.16 feet. The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The width of flume was 1.19 feet and the average depth of water at the selected cross section was 0.35 foot, giving a cross section of 0.417 square foot.

The average velocity of the water at the selected cross section was 1.867 feet per second, which gives a discharge of 0.78 second-foot, or 351 gallons a minute. From this we deduce the specific capacity of the well to be 16.3 gallons a minute, and the specific capacity for each square foot of well strainer is 0.627 gallon a minute.

The cost of fuel used for pumping can be readily estimated from careful tests by Mr. Roualt. For one irrigation of a 70-acre field of tomatoes, twenty-eight days of twenty-four hours were required, and

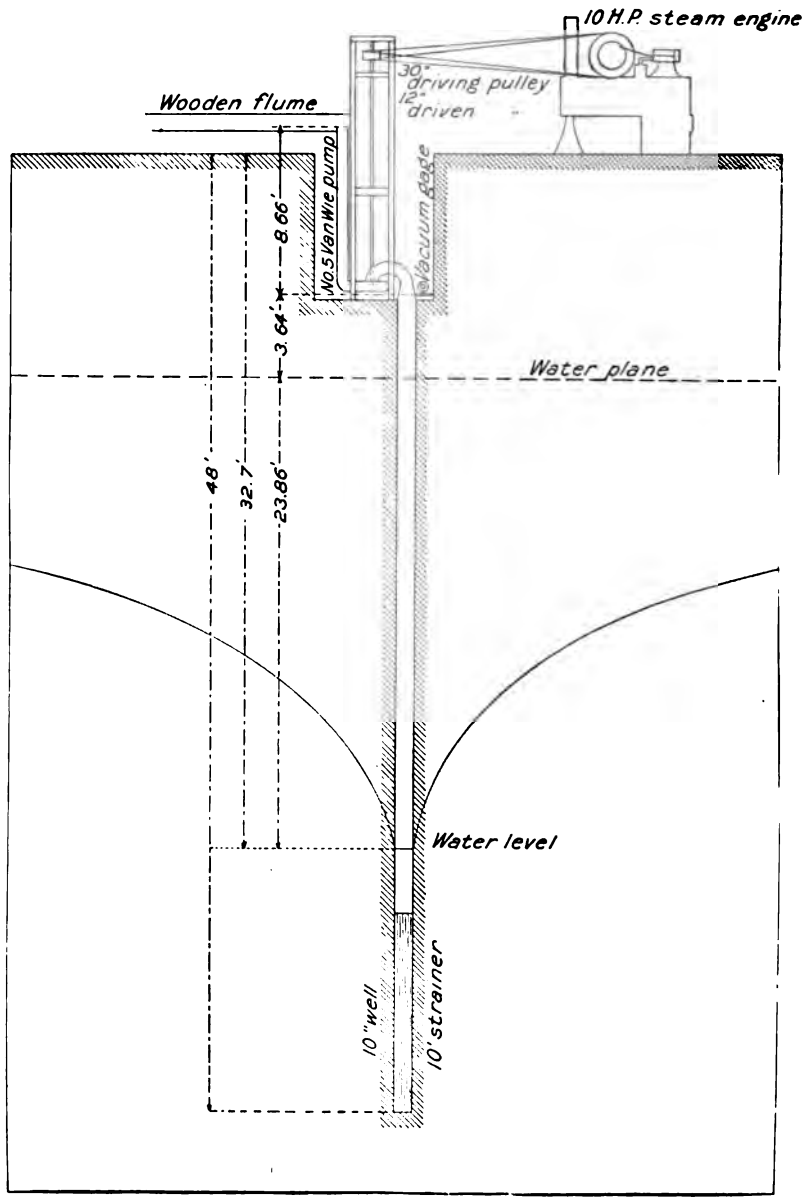



FIG. 66.—Conditions at pumping plant of Theodore Roualt near Las Cruces, N. Mex.

75 cords of cottonwood were consumed by the engine, costing $2 per cord. During the twenty-eight days of twenty-four working hours each, 14,150,000 gallons, or 43.5 acre-feet, of water were pumped.

The total cost of wood being $120, the fuel cost per 1,000 gallons of water recovered was $1.06, or $3.45 per acre-foot. The fuel cost per 1,000 foot-gallons was $0.00031, or about one thirty-second of a cent.

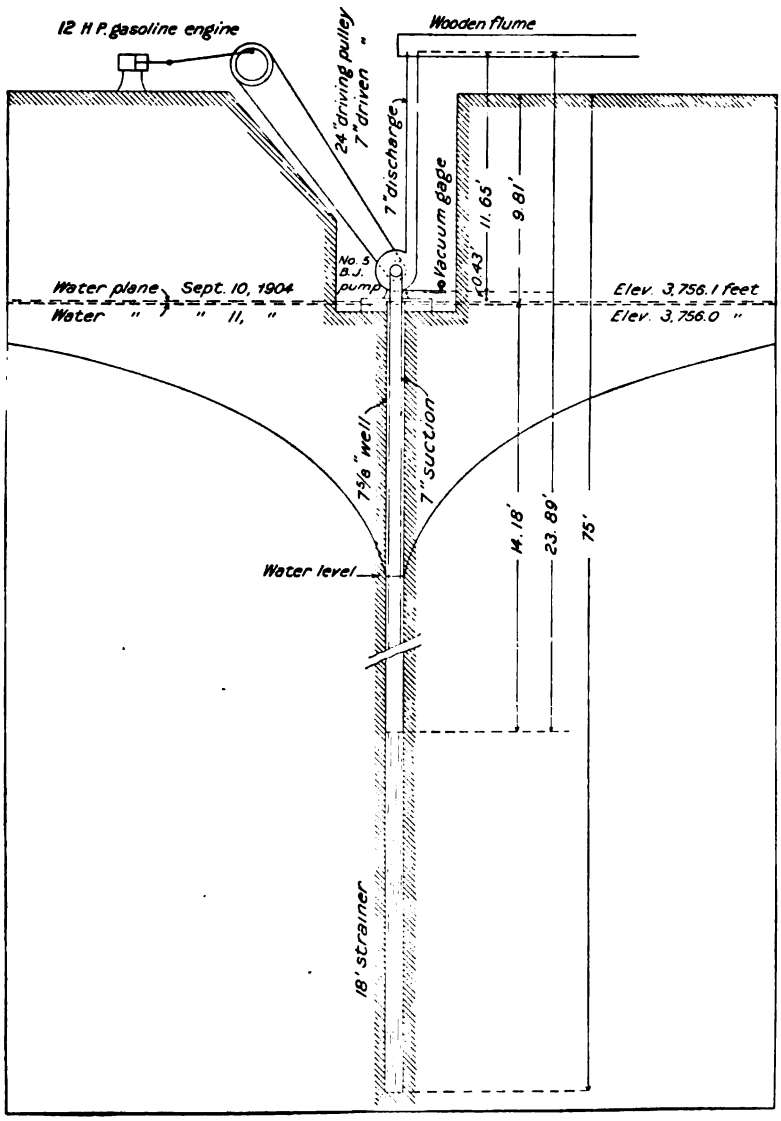



FIG. 67.—Conditions at Horaco Ranch Company's well No. 1, at Berino, N. Mex.

TEST OF HORACO RANCH COMPANY'S WELL NO. 1, BERINO, N. MEX.

Well No. 1 of the Horaco Ranch Company, at Berino, N. Mex., is 75 feet deep, constructed with 9⅝-inch casing, with 18 feet of Mott strainer. Water is delivered through a 7⅝-inch vertical discharge-

pipe opening into a horizontal wooden flume. Water is recovered by a No. 5 Byron Jackson horizontal-shaft centrifugal pump, driven by a 12-horsepower Weber gasoline engine. The engine was run at a speed of 238 revolutions a minute, the number of explosions being 106 a minute. The speed of the pump was 815 revolutions a minute, it being belted directly to the engine from a 24-inch driving and a 7-inch driven pulley.

The distance from vacuum-gage tap to the water plane on September 11, 1904, was 0.43 foot. The distance of vacuum-gage tap to top of ground was 7.1 feet, and from tap to the end of vertical discharge pipe was 8.95 feet. To this may be added 0.762 foot, the height of water jet above the end of discharge pipe, to obtain the total lift above the vacuum-gage tap. The vacuum gage read 14.5, which, when corrected for altitude, is equivalent to 12.5 inches of mercury, or 14.18 feet of water. The total lift of the pump was, therefore, 23.89 feet.

The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. At the selected cross section the average depth of the water was 0.278 foot, and the average width was 1.42 feet, giving an area of cross section of 0.395 square foot. The average velocity of the water at the selected cross section was 4.707 feet per second, from which we conclude that the discharge was 1.86 second-feet, or 837 gallons a minute.

The water level in the well was lowered 13.75 feet during pumping, and therefore the specific capacity of the well is 60.8 gallons a minute, or 1.69 gallons a minute for each square foot of well strainer.

Although the amount of water recovered at well No. 1 is very materially greater than at well No. 3, the cost for fuel is substantially the same. The amount of gasoline consumed is slightly less than 1.2 gallons an hour, which at 17 cents a gallon makes the hourly cost 20 cents. The amount of water recovered being 837 gallons a minute, or 50,220 gallons an hour, the fuel cost for each 1,000 gallons of water was $0.004, or $1.30 per acre-foot of water recovered. The lift at well No. 1 being 23.89 feet, the cost of fuel for each 1,000 foot-gallons was $0.000167, or one-sixtieth of a cent.

## SUMMARY OF RESULTS OF TESTS OF PUMPING PLANTS IN THE VALLEY OF THE RIO GRANDE IN LOWER PART OF NEW MEXICO AND WESTERN END OF TEXAS.

The accompanying table shows the results of tests of a number of pumping plants used for irrigation, and situated in the valley of the Rio Grande in the lower part of New Mexico and the western end of Texas. Most of the entries on the table explain themselves. Under the heading "Location" is given the nearest post-office to the ranch on which the pumping plants are located. The first three pumping

plants, those of Felix Martinez, W. N. French, and E. J. Hadlock, are located about 3 miles east of El Paso, Tex. The plants of J. A. Smith and J. S. Porcher are located in the valley of the Rio Grande about 8 miles east of El Paso, Tex. The pumping plants of Barker, Boyer, Burke, Carrera, Hager, Hines, Roualt, Totten, and the Agricultural College are located in the valley of the Rio Grande in the neighborhood of Las Cruces, N. Mex. The pumping plants of the Horaco Ranch Company are located near the post-office of Berino, N. Mex., which is situated 24 miles north of El Paso and 17 miles south of Las Cruces.

The fuel used in most of these pumping plants is gasoline, which term as here used includes the "distillate" manufactured from Texas crude oil, which is extensively used for fuel purposes. Its caloric value is somewhat less than that of the gasoline used in the Eastern States.

### DETERMINATION OF VACUUM.

In all of the pumping plants except the one of E. J. Hadlock water was recovered by means of centrifugal pumps, which in nearly all cases were directly coupled to the top of the well casings. In order to determine the suction of the pumps, it was necessary to drill a hole in the goose neck of the centrifugal pumps and insert the vacuum gage. The measurements to determine the distance the pumps were required to lift the water were made from this vacuum-gage tap as datum in all cases. In column 6 is given the distance the pump is required to lift the water above the vacuum-gage tap. In column 7 the vacuum reading is given in feet of water. Therefore the total lift of the pump can be found in each case by adding the corresponding numbers in columns 6 and 7. In column 8 is given the distance that the natural level of the water in the well is lowered during pumping. If the vacuum gage had been placed at the exact level of the undisturbed ground water, the readings in column 8 would be identical with those in column 7. The numbers in column 8 are less than those in column 7, because in all cases the vacuum gage stood some distance above the natural level of the water in the well.

### SPECIFIC CAPACITY.

The numbers in column 11 express the readiness with which the well furnishes water to the pump. The numbers in each case were found by dividing the numbers in column 10 by the corresponding numbers in column 8. These numbers therefore express the amount of water the well would furnish if the water level in the well was lowered but 1 foot. They constitute what is known as the "specific capacity" of the well, and are large in case of a good well and small in case of a poor well. (See Chapter VII.)

In column 12 there are given the same magnitudes as are expressed in column 11, reduced in each case to 1 square foot of well strainer.

*Results of tests of pumping plants in the valley of the Rio Grande in New Mexico and Texas.*

| 1. Name of plant. | 2. Location. | 3. Horse-power. | 4. Fuel used. | 5. Price of fuel. | 6. Lift above vacuum. | 7. Vacuum in feet of water. | 8. Amount water is lowered. | 9. Total lift. | 10. Yield gallons minute. | 11. Specific capacity. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | | *Feet.* | *Feet.* | | *Gal. min.* |
| Felix Martinez | El Paso, Tex | 10 | Electricity | 0.05 | 16.77 | 25.50 | 22.16 | 38.93 | 378 | 17.50 |
| W. N. French | do | 8 | Gasoline | .14 | 12.65 | 18.05 | 13.35 | 30.70 | 269 | 20.20 |
| E. J. Hadlock | do | 5½ | do | .14 | 5.20 | 22.60 | 13.03 | 27.80 | 258 | 19.80 |
| J. A. Smith No. 1 | do | 28 | Crude oil | .03 | 14.00 | 22.70 | 16.24 | 36.70 | 938 | 57.40 |
| J. A. Smith No. 2 | do | 22 | Gasoline | .14 | 15.45 | 26.10 | 21.00 | 41.45 | 1,325 | 63.20 |
| J. S. Porcher | do | 15 | do | .14 | 12.80 | 23.07 | 20.59 | 35.87 | 658 | 32.00 |
| F. C. Barker | Las Cruces, N. Mex | 5 | do | .17 | 20.18 | 25.40 | 22.48 | 45.58 | 131 | 5.83 |
| E. M. Boyer | do | 12 | do | .17 | 17.60 | 22.70 | 19.76 | 40.30 | 658 | 33.30 |
| F. Burke | Mesilla, N. Mex | 21 | do | .17 | 14.85 | 25.60 | 22.85 | 40.45 | 725 | 31.75 |
| J. C. Carrera | Mesilla Park, N. Mex | 8 | do | .17 | 12.65 | 14.20 | 8.48 | 26.85 | 648 | 74.60 |
| W. N. Hager | do | 12 | do | .17 | 17.17 | 17.60 | 15.20 | 34.77 | 325 | 22.30 |
| A. L. Hines | Mesilla, N. Mex | 8 | do | .17 | 19.05 | 17.00 | 14.08 | 36.05 | 271 | 19.20 |
| T. Roualt | Las Cruces, N. Mex | 10 | Wood | 2.00 | 8.66 | 25.50 | 23.86 | 34.16 | 351 | 16.00 |
| G. H. Totten | Mesilla, N. Mex | 28 | Gasoline | .17 | 16.95 | 26.40 | 22.50 | 43.35 | 464 | 20.60 |
| Agricultural College | Mesilla Park, N. Mex | 20 | Wood | 2.25 | 17.10 | 12.45 | 11.37 | 29.55 | 1,000 | 88.00 |
| Horaco Ranch Company No. 1. | Berino, N. Mex | 12 | Gasoline | .17 | 9.71 | 14.18 | 13.75 | 23.89 | 837 | 60.80 |
| Horaco Ranch Company No. 2. | do | 12 | do | .17 | 10.36 | 24.90 | 23.64 | 35.26 | 191 | 8.10 |
| Horaco Ranch Company No. 3. | do | 12 | do | .17 | 11.56 | 20.80 | 18.55 | 32.36 | 750 | 40.40 |

| 1. Name of plant. | 2. Location. | 12. Specific capacity per square foot strainer. | 13. Cost of plant. | 14. Interest and depreciation. | 15. Labor and other cost. | 16. Fuel cost per hour. | 17. Fuel cost 1,000 foot-gallons. | 18. Fuel cost per acre-foot. | 19. Total cost per acre-foot. |
|---|---|---|---|---|---|---|---|---|---|
| | | *Gal. min.* | | *Per hour.* | *Per hour.* | | *Cents.* | | |
| Felix Martinez | El Paso, Tex | 1.21 | $1,200 | $0.108 | $0.050 | $0.243 | $\frac{1}{27}$ | $3.43 | $5.75 |
| W. N. French | do | 1.37 | 800 | .072 | .120 | .112 | $\frac{1}{14}$ | 2.26 | 6.13 |
| E. J. Hadlock | do | .792 | 800 | .072 | .140 | .074 | $\frac{1}{58}$ | 1.58 | 6.02 |
| J. A. Smith No. 1 | do | 1.01 | 3,000 | .270 | .150 | .0975 | $\frac{1}{171}$ | .70 | 2.96 |
| J. A. Smith No. 2 | do | 1.37 | 2,200 | .198 | .150 | .35 | $\frac{1}{94}$ | 1.43 | 2.79 |
| J. S. Porcher | do | 1.28 | 1,500 | .135 | .150 | .21 | $\frac{1}{67}$ | 1.73 | 4.10 |
| F. C. Barker | Las Cruces, N. Mex | .337 | 1,200 | .108 | .120 | .09 | $\frac{1}{40}$ | 3.73 | 13.20 |
| E. M. Boyer | do | 1.969 | 1,200 | .108 | .150 | .163 | $\frac{1}{68}$ | 1.34 | 3.47 |
| F. Burke | Mesilla, N. Mex | .734 | 2,100 | .189 | .150 | .34 | $\frac{1}{52}$ | 2.52 | 5.17 |
| J. C. Carrera | Mesilla Park, N. Mex | 3.530 | 900 | .081 | .120 | .177 | $\frac{1}{59}$ | 1.48 | 3.16 |
| W. N. Hager | do | .760 | 1,200 | .108 | .150 | .31 | $\frac{1}{22}$ | 5.14 | 9.57 |
| A. L. Hines | Mesilla, N. Mex | 1.790 | 800 | .072 | .120 | .255 | $\frac{1}{28}$ | 5.10 | 8.95 |
| T. Roualt | Las Cruces, N. Mex | .627 | 1,200 | .108 | .180 | .223 | $\frac{1}{32}$ | 3.47 | 7.91 |
| G. H. Totten | Mesilla, N. Mex | .760 | 2,500 | .225 | .150 | .37 | $\frac{1}{33}$ | 4.34 | 7.91 |
| Agricultural College | Mesilla Park, N. Mex | 2.780 | 2,000 | .180 | .200 | .52 | $\frac{1}{34}$ | 2.83 | 4.88 |
| Horaco Ranch Company No. 1. | Berino, N. Mex | 1.690 | 992 | .090 | .090 | .16 | $\frac{1}{75}$ | 1.04 | 2.21 |
| Horaco Ranch Company No. 2. | do | .178 | 992 | .090 | .090 | .204 | $\frac{1}{30}$ | 5.80 | 10.90 |
| Horaco Ranch Company No. 3. | do | .892 | 992 | .090 | .090 | .16 | $\frac{1}{89}$ | 1.16 | 2.46 |

The numbers in this column, therefore, express the amount of water in gallons per minute furnished by 1 square foot of well strainer under a head of 1 foot of water. They are a numerical expression of the degree of coarseness of the material in which the well is placed.

### COST AND OPERATING EXPENSES.

In column 13 are given the costs of the various plants expressed in round numbers. These are in most cases an estimate at the rate of $100 per horsepower for the total cost of engine, pump, and wells. In a few special cases the cost is at a higher rate than the above. In estimating the expense of operating the various plants, the depreciation in the total value of the plant has been taken at 10 per cent, and the rate of interest at 8 per cent. It is difficult to make an accurate estimate of the amount of cost that should be charged up to the water recovered by an irrigation plant, on account of the presence of several unknown factors. If the plants were in operation every day in the year it would be relatively easy to make an accurate estimate of these factors in the operating expense. As it is, the plants are in operation for a longer or shorter period, depending upon circumstances, which vary from year to year. Most of the plants are used merely as an auxiliary to the supply of ditch water. In making the estimate of the charge for interest and depreciation it has been assumed that the plants are in operation for two thousand hours each season. This corresponds to a continuous twenty-four hours' daily use for three months, or two hundred days of ten hours each, and probably represents a fair average of the actual conditions.

In column 15 there is given a charge for labor and other expenses, including oil, batteries, and such other incidental expenses as are not properly included under the head of depreciation. The operation of the gasoline plants can easily be put in charge of unskilled labor, and for the smaller plants full time is not required of such labor.

### FUEL COST.

That part of the operating expenses which is properly chargeable to fuel cost can be accurately determined. Column 16 expresses the cost for fuel per hour at the various plants. Column 18 expresses the cost per acre-foot of water recovered. In column 17 there is given the cost of fuel for lifting 1,000 gallons of water through a distance of 1 foot. For the purpose of comparison the results are expressed in fractional parts of a cent.

In column 5 is given the price of fuel. The price of gasoline is given in cents per gallon in barrel lots. The price of electricity is given in cents per kilowatt hour. Cost of wood at the ranch of T. Roualt is the cost of cottonwood per cord. The price of wood at the Agricultural College of $2.25 per cord is the rate for small Tornillo wood, which has a higher caloric value than the cottonwood used by Roualt.

COMMENTS ON THE RIO GRANDE PUMPING PLANTS.

The pumping plants of Martinez, French, Hadlock, Smith, and Porcher are all located in the bottom lands of the Rio Grande from 3 to 8 miles east of El Paso, Tex. From column 12 of the table it will be seen that the specific capacities of these wells per square foot of well strainer are nearly the same at the plants of Martinez, French, Smith No. 2, and Porcher, varying only between 1.21 gallons a minute at Martinez's well to 1.37 at French's well. These numbers, it should be remembered, give the amount of water furnished by each square foot of well strainer for 1 foot head of water. The numbers express, therefore, the degree of coarseness of the material in which the strainer is placed, provided, of course, that the well strainers themselves offer little or no resistance to the admission of water to the well. The specific capacity per square foot of strainer at the Smith plant No. 1 and the Hadlock plant is much smaller than the others. In the case of the Hadlock well there is no doubt but that this result is due to the fact that three of the Hadlock wells draw from surface water above a clay which overlies the sand and gravel from which the fourth well and the neighboring wells of Martinez and French draw their supply. In addition to this the strainers on these three wells of Hadlock consist of nothing but common pipe with drilled round holes. This poor form of strainer is sufficient in itself to cut down very materially the specific capacity of the wells.

The low specific capacity at Smith's plant No. 1 is probably due chiefly to a local deposit of fine-sized water-bearing sand. There is no covering layer of clay over the water-bearing sands and gravels at the location of these wells. The sands contain so little coarse material that fine sand is constantly being drawn into the wells by the pumps. This draft on the sand deposit at the east of the three wells at Smith's plant No. 1 is such that several wagon loads of gravel have been hauled from time to time and placed in the pit of the east well to replace the sand removed by the pumps.

The tests of the nine wells in the Rio Grande Valley near Las Cruces, N. Mex., form an interesting study. If we arrange them in order of their specific capacities per square foot of well strainer the list is as follows:

*Specific capacity, per square foot of strainer, of nine wells in Rio Grande Valley near Las Cruces, N. Mex.*

| Name of well. | Gals. per min. | Name of well. | Gals. per min. |
|---|---|---|---|
| Carrera | 3.530 | Hager | 0.760 |
| Agricultural college | 2.320 | Totten | .760 |
| Boyer | 1.969 | Roualt | .627 |
| Hines | 1.790 | Barker | .337 |
| Burke | .934 | | |

The first three wells are located near the eastern edge of the river channel, and the high specific capacity of the wells is undoubtedly due to coarse mountain débris which has been deposited along the eroded edge of the mesa. The high specific capacity at Hines's plant seems to be exceptional to the general lower average prevailing in the intermediate district lying between the border of the mesa and the river channel, as is represented by the plants of Hager, Totten, Burke, and Barker. The low specific capacity of the Barker well is due in part to its small diameter, and it is to be classed, therefore, with the Burke, Totten, and Hager wells rather than with the Roualt well. This last well is close to the river channel. Its low specific capacity is an indication of the progressive fineness of the deposits as we approach the river from the mesa.

It should be considered that the specific capacities of the wells first named in above list are exceptionally high rather than that the others in the list are exceptionally low. Even the specific capacity of the Roualt well, of over one-third of a gallon a minute per square foot of well strainer, would be considered high in many parts of the country.

The specific capacity of the three wells on the Horaco ranch, near Berino, N. Mex., presents an interesting study. These plants are located but a few hundred feet apart and are identical in all respects except in the depth of the wells. The wells are 9⅝ inches in diameter, and each has 18 linear feet of well strainer at the bottom, formed by drilling 1½-inch holes in the 9⅝-inch casing and wrapping the casing with No. 8 galvanized-iron wire, leaving one-eighth inch space between. The enormous difference in the specific capacities of these wells is entirely due to the fact that No. 1 is 75 feet deep, No. 2 is 53 feet deep, and No. 3 is 62 feet deep. The small expense necessary to sink well No. 2 from a depth of 53 feet to a depth of 75 feet will change the cost of the water recovered from $10.90 per acre-foot to $2.21 per acre-foot.

The group of pumping plants near Las Cruces are for the most part very recently constructed, and changes will undoubtedly be made in many of the plants, based upon the experience of the present irrigation season. The wells at the Agricultural College were the first ones constructed in this part of the valley, and an excellent report of tests on these wells by Professors Vernon and Lester was issued in April, 1903. The very high specific capacity of the college wells has had its influence upon the construction of the other plants. With a few exceptions, we may say that the pumping plants in the Mesilla Valley have engines and pumps entirely too large for the wells, or, as may be preferably stated, the wells are too small for the pumps and engines. By comparing the high lifts recorded in column 9 of the table with the amount of lowering of the water in the wells, which is recorded in column 8, it will be seen that the lift of many of the plants can be considerably decreased by increasing the amount of strainer surface in the wells.

In most cases this will mean the construction of additional wells, as the strainer surface can not be otherwise sufficiently increased. The necessity of keeping the lift of the pump down to a minimum is greatly emphasized in irrigation plants, and large strainer surface is the first requisite.

The efficiency of the smaller plants can also be increased by the construction of storage reservoirs or ponds for the accumulation of water before it is used for irrigation. In this way the duty of the water can be considerably increased. Barker's plant is the only one having such reservoirs. For plants that yield over a second-foot of water the reservoir is undoubtedly of little additional value.

The determination of the speeds of the centrifugal pumps at the various plants showed that in many cases the speed had not been properly adjusted. In all cases the speeds were too high. This was undoubtedly due to the fact that the vacuum had never been determined, so that the total lift of the pump was unknown.

# INDEX.


Page.

Agawam Pond, Long Island, influence of, on underflow ..... 72-75
Agawam pumping station, Long Island, influence of, on underflow ..... 81-83
Ammeter, recording, character of ..... 26
charts of, plate showing ..... 26
plate showing ..... 26
Artesian well, California, view of ..... 102
Artesian wells, specific capacity of ..... 86, 89
Berino, N. Mex., pumping plants at, figure showing ..... 111
pumping plants at, test of ..... 111-112, 118
Brooklyn, N. Y., pumping stations of ..... 65
pumping stations of, ground water at .. 65-69
ground water at, influence of pumping on ..... 81-85
influence of rainfall on ..... 69-72
influence of seepage on ..... 72-80
underflow at ..... 66-67
Buckets for charging wells, plate showing. 18
California, southern, ground water conditions in ..... 98
wells in, yield of ..... 103
California stovepipe method of well construction. *See* Wells, construction of.
Casing, well, perforator for, figures showing. 100
view of ..... 98
Commutator clock, description of ..... 26
plate showing ..... 20
Coupling, hydraulic, figure showing ..... 17
El Paso, Tex., pumping plants near, figure showing ..... 105, 107
pumping plants near, test of ..... 104-109
Electrical method of determining underflow, accuracy of ..... 49
Electrode, plate showing ..... 18
Electrolytes, character of ..... 20-21, 24-25
Flow, relative, definition of ..... 13
Formalin, effect of ..... 30
Friction in wells, influence of ..... 88
Garden, Kans., test wells at, figure showing. 10
underflow at, measurements of, ampere curves of, figure showing ..... 27
well and plant at, specific capacity of .. 91-94
Gravel. *See* Sand and gravel.
Horaco Ranch Co., pumping plant of, figure showing ..... 111
pumping plant of, test of ..... 111-112
Inertia, absence of, in ground water ..... 70-71
Kansas, Finney Co., well and plant in, specific capacity of ..... 95-97

Page.

Las Cruces, N. Mex., pumping plants at, figure showing ..... 110
pumping plants at, test of .... 109-111, 118-119
Logan, D. H., well and plant of, specific capacity of ..... 91-94
Long Beach, Cal., artesian well at, view of. 102
Long Island, N. Y., underflow on ..... 65-85
underflow on, influence of pumping on. 81-85
influence of rainfall on ..... 69-72
influence of seepage on ..... 72-81
measurements of, ampere curves of, figures showing ..... 24, 68, 70-81
underflow stations on, maps showing .. 82-84
Martinez, Felix, pumping plant of, figure showing ..... 105
pumping plant of, test of ..... 104-106
Meter, underflow, direct-reading type of, description of ..... 19-25
direct-reading type of, plate showing .. 20
recording type of, description of ..... 25-28
types of, description of ..... 16, 19-28
use of, figure showing ..... 20
Mohave River, Cal., narrows of, cross section at ..... 57
narrows of, driving test wells at, view of ..... 56, 58
map of ..... 56
underflow measurements at ..... 55-63
ampere curves of, figures showing ..... 58-62
underflow station at, plan of ..... 57
view of ..... 56
water of, quality of ..... 63-64
temperature of ..... 64
New Mexico, pumping plants in, figures showing ..... 110, 111
pumping plants in, tests of ..... 109-119
Pond seepage, influence of, on ground water on Long Island ..... 72-81
Proctor, J. B., well rig of ..... 102
Pumping plants, tests of ..... 91-97, 104-119
Rainfall, influence of, on underflow on Long Island ..... 69-72
Reservoir seepage, influence of, on ground water on Long Island ..... 72-81
Richter, Minnie, well and plant of, specific capacity of ..... 95-97
Riggle, E. W., well rig of ..... 102
Rio Grande, pumping plants on, costs at ... 116
pumping plants on, specific capacities of ..... 113-119
tests of ..... 112-119

Page.
Rio Hondo, Cal., underflow measurements of ..... 50–54
underflow measurements of, ampere curves of ..... 52
record of ..... 21
Roualt, Theodore, pumping plant of, figure showing ..... 110
pumping plant of, test of ..... 109–111
Sal ammoniac, use of ..... 24
San Gabriel River, Cal., underflow measurements of ..... 50–54
underflow measurements of, ampere curves of, figure showing ..... 22, 54
record of ..... 21
Sand and gravel, flow through, speed of, accuracy of electrical method of determination of ..... 49
particles of, size of, influence of. 10–11, 15, 87–88
transmission capacity of ..... 10–15
factors influencing ..... 10, 87–88
laboratory experiments on ..... 29–49
transmission constants of ..... 10–15
diagram of ..... 14
table of ..... 12, 15
Smith, J. A., pumping plant of, figure showing ..... 107
pumping plant of, test of ..... 106–109
Specific capacity of wells ..... 86–97
definition of ..... 86–87
estimation of ..... 90
factors influencing ..... 87–89
Stovepipe method of well construction. *See* Wells, construction of.
Tank, horizontal, experiments on flow in ..... 29–41
experiments on flow in, figures showing ..... 33–40
figure showing ..... 31
Tank, vertical, experiments on flow in ..... 41–48
experiments on flow in, figures showing ..... 43–47
figures showing ..... 42, 43
Temperature, effect of, on flow through sand ..... 13

Page.
Test wells, arrangement of ..... 16–19
arrangement of, figure showing ..... 18
charging of, apparatus for, plate showing ..... 18
driving of, apparatus for, plate showing ..... 18, 58
Texas, pumping plants in, figures showing ..... 105, 107
pumping plants in, tests of ... 104–109, 112–119
Underflow, electrical method of determining accuracy of ..... 49
velocity of, variation of, figure illustrating ..... 46
Wantagh Pond, Long Island, influence of, on underflow ..... 75–80
underflow station at, map showing .... 84
Wantagh pumping station, Long Island, influence of, on underflow ..... 83–85
Water-bearing stratum, influence of, on yield ..... 88
Well, artesian, view of ..... 102
Well rig, jetting, description of ..... 17
plate showing ..... 26
Well rigs, California, types of ..... 102–103
views of ..... 100, 102
Wells, casing of. *See* Casing.
construction of, California, stovepipe method of ..... 98–103
advantages of ..... 101
cost of ..... 101–102
method of ..... 98–100
starter for, view of ..... 98
diameter of, importance of ..... 88
interference of ..... 71–72
specific capacity of. *See* Specific capacity of wells.
water in, rate of rise of ..... 91
rate of rise of, curves of, figure showing ..... 94
measurement of, apparatus for, figure showing ..... 90
wiring of, methods of ..... 19–20, 26
Wells, test. *See* Test wells.
Wiring of wells, methods of ..... 19–20, 26

O

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DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

# OBSERVATIONS

ON THE

# GROUND WATERS OF RIO GRANDE VALLEY

BY

CHARLES S. SLICHTER

WASHINGTON

GOVERNMENT PRINTING OFFICE

1905

# CONTENTS.


| | Page. |
|---|---|
| LETTER OF TRANSMITTAL | 7 |
| CHAPTER I.—Investigation of the underflow at the narrows of the Rio Grande near El Paso, Tex | 9 |
| CHAPTER II.—Ground waters below El Paso, Tex | 14 |
| CHAPTER III.—Examination of ground-water supplies in the Mesilla Valley | 22 |
| Test wells | 24 |
| Source of the underflow | 25 |
| Indications of the amount of ground water available | 28 |
| Necessity for deep wells | 29 |
| Observations at Berino, N. Mex | 30 |
| CHAPTER IV.—Summary of tests of pumping plants in southern New Mexico and trans-Pecos, Tex | 31 |
| Determination of vacuum | 31 |
| Specific capacity | 32 |
| Cost and operating expenses | 32 |
| Fuel cost | 33 |
| Comments on the Rio Grande pumping plants | 36 |
| CHAPTER V.—Details of tests of pumping plants | 39 |
| Plants near El Paso, Tex | 39 |
| E. J. Hadlock | 39 |
| W. N. French | 41 |
| Felix Martinez | 43 |
| J. A. Smith | 45 |
| J. S. Porcher | 49 |
| Plants in Mesilla Valley, N. Mex | 51 |
| F. C. Barker | 51 |
| J. C. Carrera | 53 |
| Frank Burke | 53 |
| Mrs. E. M. Boyer | 56 |
| W. N. Hager | 58 |
| A. L. Hines | 59 |
| Theodore Roualt | 61 |
| G. H. Totten | 63 |
| Agricultural College | 65 |
| Plants near Berino, N. Mex | 67 |
| Horaco Ranch Company | 67 |
| APPENDIX.—Analysis of well water and data concerning wells at and near El Paso, Tex | 74 |
| INDEX | 81 |

# ILLUSTRATIONS.


| | | Page. |
|---|---|---|
| PLATE I. | *A*, Gorge of the Rio Grande above El Paso, Tex.; *B*, Washing down test pipe at the gorge of the Rio Grande | 10 |
| II. | *A*, California well rig; *B*, Porcher strainer | 16 |
| III. | *A*, Small rig for drilling wells for stock; *B*, Timber on Sacramento Mountains | 20 |
| IV. | Diagram showing variation in elevation of ground water in the east-west line of test wells from September 20, 1904, to March 26, 1905 | 26 |
| V. | *A*, Discharge from well No. 1, Horaco Ranch Company; *B*, Pumping plant of T. Roualt | 62 |
| FIG. 1. | Topographic map of the gorge of the Rio Grande above El Paso, Tex., where the underflow movements were made | 10 |
| 2. | Cross section of the gorge of the Rio Grande above El Paso, Tex., at the site of the proposed international dam | 11 |
| 3. | Diagram showing the variation with the depth of the total solids and chlorine in the ground water at the gorge or narrows of the Rio Grande above El Paso | 12 |
| 4. | Map showing location of wells and pumping plants in the valley and on the mesa east of El Paso, Tex | 15 |
| 5. | Section through the mesa near El Paso, from Hereford to French's pumping plant, showing water-bearing sands and position of the water plane | 16 |
| 6. | Elevation of water plane at Porcher's well No. 1 | 19 |
| 7. | Water plane between Porcher's and Smith's pumping plants and the Rio Grande on September 5, 1904 | 19 |
| 8. | Map showing wells near Mesilla Park, N. Mex | 23 |
| 9. | Position of the water plane September 19, 1904, in the two lines of test wells shown in fig. 4 | 24 |
| 10. | Cross section of part of Rio Grande Valley at Berino, N. Mex., showing position of the water plane on September 16, 1904 | 30 |
| 11. | Plan showing arrangement of wells at Hadlock's pumping plant | 39 |
| 12. | Elevation of wells at Hadlock's pumping plant near El Paso, Tex | 40 |
| 13. | Diagram of pumping plant of W. N. French, near El Paso, Tex | 42 |
| 14. | Diagram of pumping plant of Felix Martinez, near El Paso, Tex | 44 |
| 15. | Diagram of J. A. Smith's pumping plant No. 1, near El Paso, Tex | 45 |
| 16. | Diagram of J. A. Smith's pumping plant No. 2, near El Paso, Tex | 48 |
| 17. | Diagram of pumping plant of J. S. Porcher, near El Paso, Tex | 50 |
| 18. | Diagram of pumping plant of F. C. Barker, near Las Cruces, N. Mex | 52 |
| 19. | Diagram of pumping plant of J. C. Carrera, near Las Cruces, N. Mex | 54 |
| 20. | Diagram of pumping plant of F. Burke, near Mesilla Park, N. Mex | 55 |
| 21. | Diagram of pumping plant of Mrs. E. M. Boyer, near Las Cruces, N. Mex | 57 |
| 22. | Diagram of pumping plant of W. N. Hager, near Mesilla, N. Mex | 58 |
| 23. | Diagram of pumping plant of A. L. Hines, near Mesilla, N. Mex | 60 |

Page.

FIG. 24. Diagram of pumping plant of T. Roualt, near Las Cruces, N. Mex... 62
25. Diagram of pumping plant of G. H. Totten, near Mesilla, N. Mex.... 64
26. Parabola of discharge from flume at Totten's well..... 65
27. Diagram of Agricultural College, 12-inch well, Mesilla Park, N. Mex.. 66
28. Plan of pumping plants of the Horaco Ranch Company, Berino, N. Mex..... 67
29. Diagram of pumping plant No. 3, Horaco Ranch Company..... 68
30. Diagram of pumping plant No. 1, Horaco Ranch Company..... 70
31. Diagram of pumping plant No. 2, Horaco Ranch Company..... 71
32. Wells at Fort Bliss station, El Paso and Northeastern Railroad..... 78

# LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
RECLAMATION SERVICE,
*Washington, D. C., January 12, 1905.*

SIR: I transmit herewith a manuscript by Prof. Chas. S. Slichter, entitled "Observations on the Ground Waters of Rio Grande Valley," and request that it be published as one of the series of Water-Supply and Irrigation Papers. This report contains results of recent investigations in connection with the underground-water problems of Rio Grande Valley, and it is believed that the facts made available will be of general interest and value.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
*Director United States Geological Survey.*

# OBSERVATIONS ON THE GROUND WATERS OF RIO GRANDE VALLEY.

By CHARLES S. SLICHTER.

## CHAPTER I.

### INVESTIGATION OF THE UNDERFLOW AT THE NARROWS OF THE RIO GRANDE NEAR EL PASO, TEX.

An investigation of the underflow of the Rio Grande was begun in the latter part of August, 1904, at the narrows of the Rio Grande, a few miles above El Paso, Tex., where the stream flows through a narrow gorge of limestone. At this place is the site of the proposed Mexican-American international dam. At the surface of the water the distance between the walls of the gorge is less than 400 feet. The dam site has been investigated by the International (Water) Boundary Commission, organized by the joint action of the American and Mexican Governments, and maps and reports concerning the proposed dam will be found in the Proceedings of the International (Water) Boundary Commission, vol. 2, page 277.

A brief reconnaissance at the site of the proposed international dam indicated that there could be no underflow of any magnitude at this point. The distance between the walls of the gorge is less than 400 feet, and the test borings made by the Mexican commission in 1897 seemed to indicate that the maximum depth to bed rock is 86 feet. A cross section of the gorge, based upon the Mexican borings, is shown in fig. 2. In this diagram the vertical and horizontal scale are the same. A cross section of less than 40,000 square feet could not transmit a large volume of ground water even if other conditions were favorable. The highest velocity ever determined for ground water is about 100 feet in twenty-four hours, and assuming this maximum velocity at the above cross section, and a porosity of one-third in the water-bearing sands and gravel, the daily discharge would be 1,333,000 cubic feet, or 15½ cubic feet per second. The gradient of the water plane at the narrows is but $3\frac{8}{10}$ feet to the mile, and all other indications point to a low rather than a high velocity.

None of the usual indications of an underflow were found at this point. If there was a true underflow a stream undoubtedly would

flow perennially in the narrowest part of the gorge. Some miles above the site of the dam the valley broadens and is 2 to 5 miles in width, the sides gradually converging as the gorge is approached. The diminishing cross section would cause any underflow waters in the

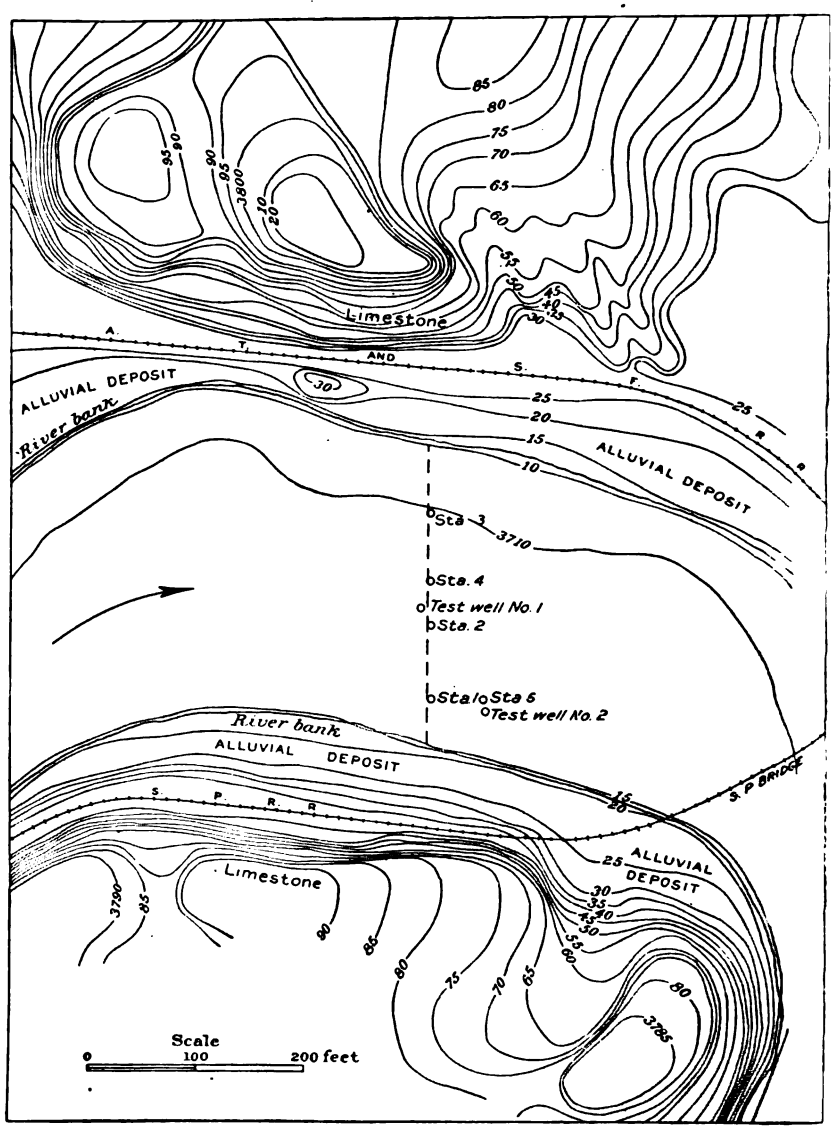



FIG. 1.—Topographic map of the gorge of the Rio Grande above El Paso Tex., where the underflow measurements were made.

valley above the narrows to seek relief at the surface in the narrow gorge and form a perennial flowing stream. Instead of this being the case the river is perfectly dry at the gorge when it ceases to flow above

*A*. GORGE OF THE RIO GRANDE ABOVE EL PASO, TEX.

*B* WASHING DOWN TEST PIPE AT THE GORGE OF THE RIO GRANDE.

the pass. It was dry during several months of 1904. In addition to a perennial surface flow through the narrowest portion of and above the gorge and near its converging sides, the ground waters should have a slightly artesian character. None of these common indications of an underflow were found.

Notwithstanding the above considerations, actual determinations of the rate of underflow were begun, largely on account of a local popular belief that there is an enormous underflow at this point. The results of the investigation are in accordance with general considerations above indicated.

The material in the river bed at the site of the proposed international dam consists of sand and fine gravel with occasional layers of silt. No bowlders were encountered in sinking the test wells and the borings were made with great ease. The ground waters in the sands of the gorge were found to contain a large amount of dissolved solids.

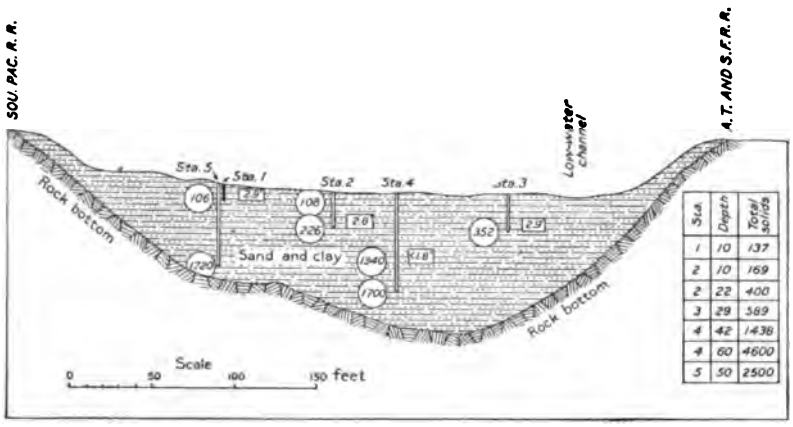



FIG. 2.—Cross section of the gorge of the Rio Grande, above El Paso, Tex., at the site of the proposed international dam.

The numbers inclosed in the rectangles give the velocity of the ground water in feet per twenty-four hours. The numbers inclosed in circles give the amount of common salt in parts per 100,000 dissolved in the ground water. The table at the right gives the depths of the test wells and the amount of total solids found in the water. The supposed rock bottom is given as determined by the Mexican borings, the vertical and horizontal scales being alike.

At a depth of 10 feet the waters contained about 100 parts per 100,000 of common salt, and the quantity became larger as distance from the surface increased. Below a depth of 32 feet so much salt was present that it was very difficult to determine the rate of motion of the ground waters. At a depth of 42 feet the common salt in solution amounted to 1,340 parts per 100,000; at 60 feet it reached 1,700 parts per 100,000; in a 50-foot test hole it amounted to 1,720 parts per 100,000. The total solids dissolved in the ground water were proportionately as large as the amount of common salt, so that at a depth of 40 feet the water was about half as strong as sea water, and at a depth of 60 feet it was

about 30 per cent stronger than ordinary sea water. In fig. 2 the positions of the principal test wells are shown.

The velocities as found at stations 1, 2, and 3 were very uniform, being 2.9 feet per twenty-four hours at station 1, 2.8 feet per twenty-four hours at station 2, and 2.9 feet per twenty-four hours at station 3. The greatest depth at which it was practicable to make a determination of the rate of flow was 42 feet, where the common salt in solution amounted to about 1,400 parts per 100,000. In order to increase the conductivity of this water, it was necessary to make use of a stronger electrolyte than ammonium chloride. For this purpose a quantity of ammonium chloride was saturated with a gallon and a half of hydrochloric acid. This mixture was used to salt the upstream well used for determining the rate of the underflow. From the way the apparatus worked it was evident that it is possible to determine the rate of movement of ground waters as strong in salt as the water of the Rio Grande

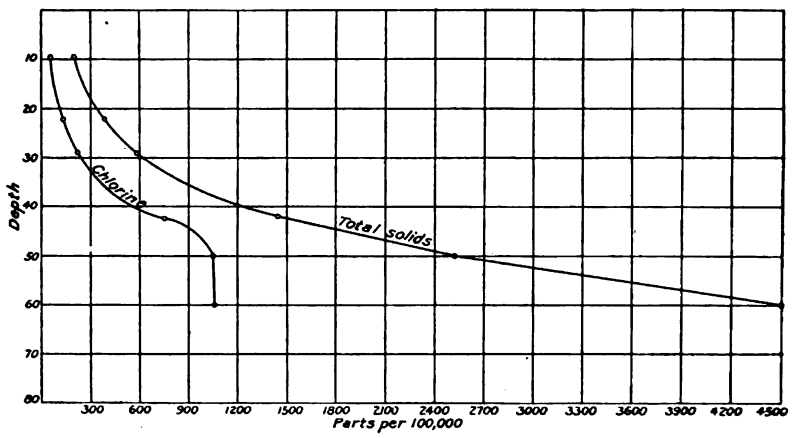



FIG. 3.—Diagram showing the variation with depth of the total solids and chlorine in the ground water at the gorge or narrows of the Rio Grande above El Paso.

The rapid rate of increase in the dissolved solids at a depth of about 40 feet indicates that the water below such depth is stagnant or without appreciable movement.

at a depth of 42 feet; as a matter of fact, however, the water at this depth is either stationary or moves much slower than at higher levels. After waiting three days none of the electrolytes had reached the downstream wells, and it was concluded that there was practically no motion of the ground water at this depth. A few of the test wells were driven to a greater depth, in order to secure samples of the water and to note the amount of contained solids, but no measurements of the rate of motion of the waters were attempted. Fig. 3 represents by curves the variation of the chlorine,[a] and total solids with the depth as determined from the various test wells. This diagram suggests that the water below the 35- or 40-foot level is not moving. The

[a] The amount of common salt is proportional to the chlorine.

increase in total solids is not uniform, but becomes greater below the 35-foot line. The amount of chlorine shows a similar jump at about the same depth, but after increasing suddenly it seems to remain stationary. This may be due to the fact that the common salt in solution originates above the gorge, and has been slowly concentrated during a long time. The total solids, on the contrary, include the dissolved salts of lime, which can become almost indefinitely concentrated from the limestone débris in the gravels of the gorge itself.

It would be interesting to know whether the depth of the most sudden increase in the dissolved salts (say 35 feet) corresponds to the depth of the maximum scour of the river at the gorge.

The velocities of the ground water in the tests described above are undoubtedly the maximum velocities in the narrows of the gorge, since pains were taken to make the tests in the coarsest strata encountered in the borings. Layers of fine silt were frequently met with in putting down the test wells, which probably accounts for the stagnant condition of the water below the 35-foot level. These layers of silt are undoubtedly imbricated in such a way that movement of the deeper ground waters is impossible.

The total cross section in which the ground waters move is about 35 feet in depth and 325 feet in width and has an area of 11,200 square feet. If it is assumed that the porosity of the material is one-third and the maximum velocity of the ground water is 3 feet per day, the total discharge through the gorge does not exceed 11,200 cubic feet per twenty-four hours, or about 0.132 cubic foot per second, or about 50 gallons a minute. This amount of underflow is entirely insignificant. It is obvious that on account of the enormous quantity of dissolved solids the underflow would be worthless, no matter what its magnitude might be.

# CHAPTER II.

## GROUND WATERS BELOW EL PASO, TEX.

The Rio Grande Valley below El Paso has been studied with reference to possibility of obtaining a ground-water supply from wells. East and north of El Paso is a very level strip of country known as the "Lanoria Mesa." This mesa lies between 4,000 and 5,000 feet above the sea level, and extends as a nearly unbroken plain between two north-south ranges of mountains. On the west the mesa is limited by the Franklin, Organ, and San Andres mountains, to the east it is bordered by the Hueco Mountains, and farther north by the Sacramento Mountains. At the southern end the east and west extent of the mesa is about 20 miles, and at the north it is almost unbroken for 100 miles. The north end of the mesa is interesting on account of several very unusual topographic features. A number of miles west and north of Alamogordo, N. Mex., are depressions which are said to be the channels of an ancient river. A great overflow of lava covers the northern portion of the mesa, and apparently hides the bank of the ancient river channel. About 18 miles north and west of Alamogordo are found the famous "white sands" of New Mexico, which consist of wind-blown hillocks of granular grains of gypsum. The white sands belt has, east to west, a width of 5 to 18 miles, a length north to south of about 40 miles, and an area of nearly 600 square miles.

In the northern portion of the Lanoria Mesa good wells are very rare, and at many places are quite unknown. The ground waters for the most part are highly alkaline and unsatisfactory for use. Running water can be noticed in many places flowing beneath the lava bed, forming a subterranean stream locally called the "Lost River."

In the southern portion of the mesa within 20 miles of the Rio Grande is a very fine-grained, water-bearing sand at a depth of about 230 feet. The water-bearing stratum is between 30 and 60 feet thick where it has been found and the contained water is of an excellent quality. The strongly alkaline waters common in the northern part of the mesa seem to be entirely absent from this portion. The water-

bearing sand, however, is too fine grained to furnish wells of large capacity. The origin of ground water in this sand stratum is difficult

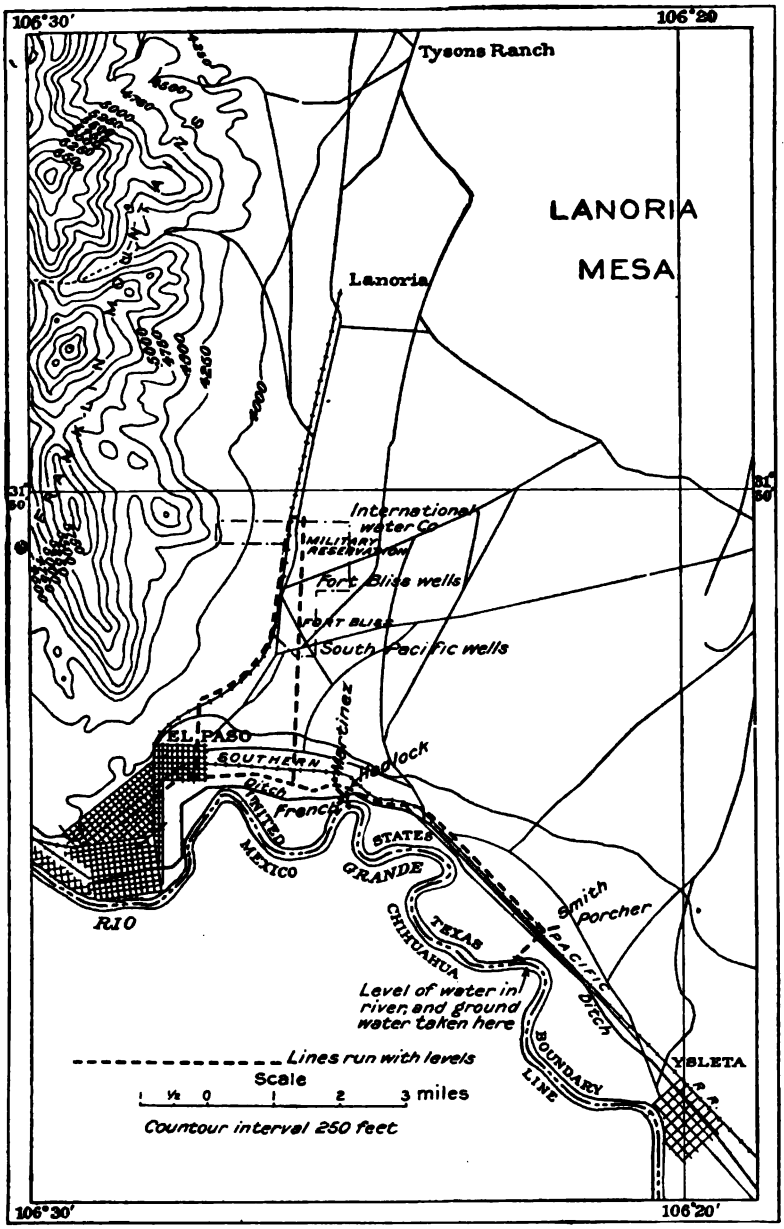



FIG. 4.—Map showing location of wells and pumping plants in the valley and on the mesa east of El Paso. The lines run with level are shown.

to trace. Nearly everywhere in the southern part of the mesa there is within a few feet of the surface from 3 to 6 feet of "caliche," a

cemented calcareous impervious conglomerate that prevents the seepage of ground water. The deposit of "caliche" seems to be the result

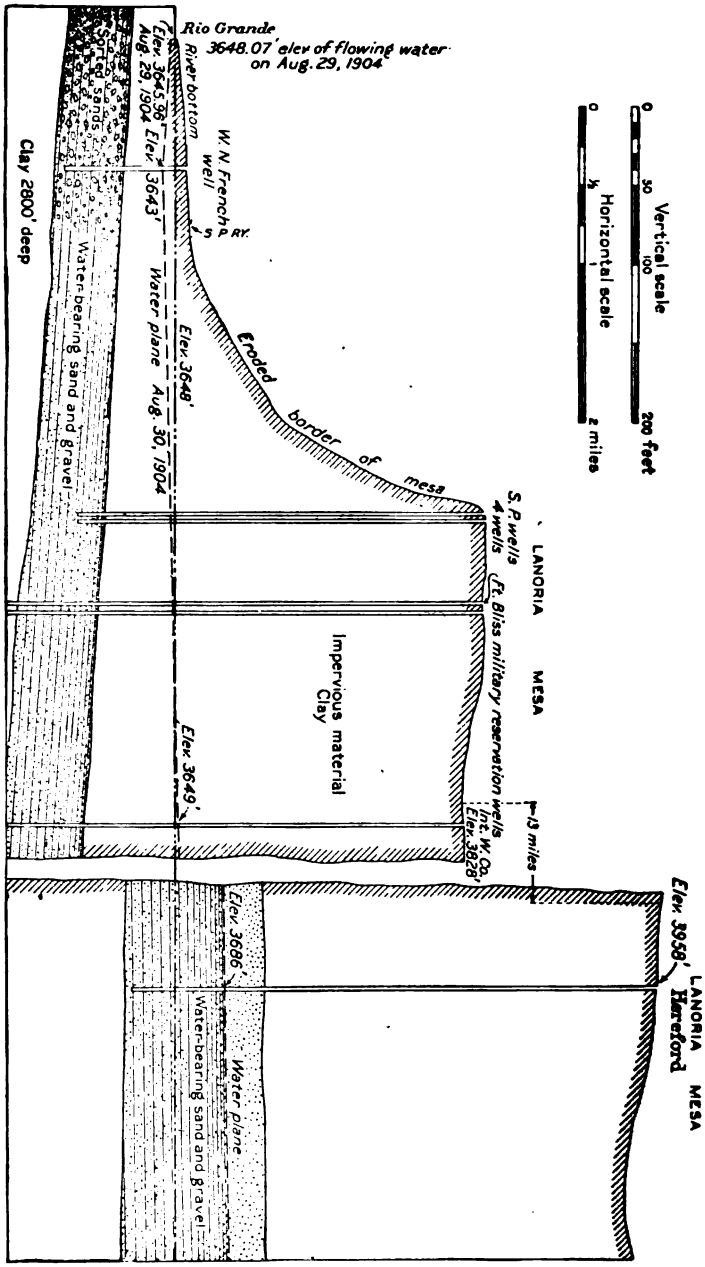
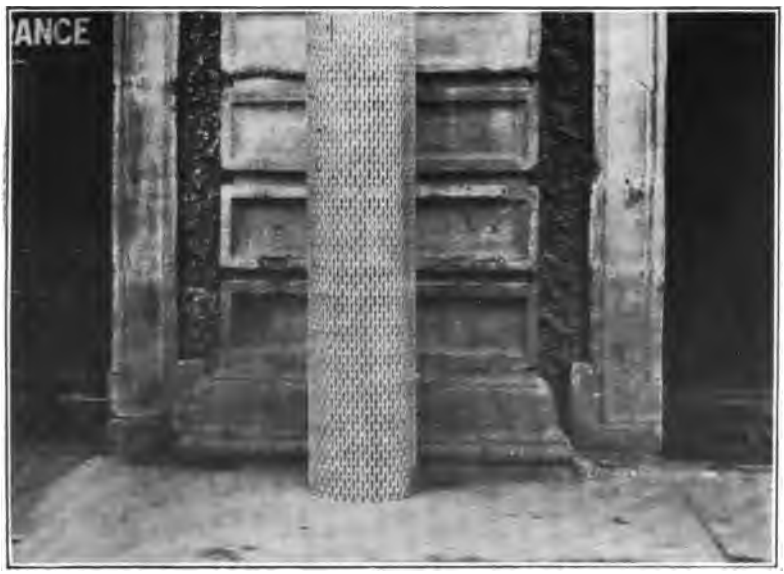



Fig. 5.—Section through Lanoria Mesa near El Paso, from Hereford to French's pumping plant, showing water-bearing sands and position of the water plane.

of the evaporation of the ground water near the surface of the mesa. Whenever this "caliche" is present the rainfall is undoubtedly unable

*A.* CALIFORNIA WELL RIG.




*B.* PORCHER STRAINER.

to penetrate the ground for a distance of more than a few feet. The annual precipitation is so slight, not exceeding a total of 9 inches, that the portion that sinks into the ground must soon be evaporated by the intense heat of the sun wherever the "caliche" is present.

It is difficult to believe that the ground water in the stratum of sand referred to above is derived from the run-off from the north-south mountain ranges. These mountain ranges consist very largely of limestone; and the small canyon streams run high in calcium, but the waters found in the sand stratum are very soft and show no indication of having originated in a calcareous catchment area. The most probable source of the water of the sand stratum of the mesa is the rainfall on the mesa itself, especially on limited portions located between 12 and 25 miles north of the Rio Grande. Part of the surface material on the mesa near Hereford is very sandy and is fairly well adapted to receive and absorb a considerable part of the light rainfall. The railroad wells drilled at this point indicate that only a fractional part of the sand stratum is saturated with water, while in the lower part of the mesa in the neighborhood of Fort Bliss, near the valley of the Rio Grande, the water in the sand is found under an artesian head. These facts are brought out in fig. 5. As will be seen by inspection of this diagram, the source of the ground water found in the deep-lying sands and gravels should be sought in the neighborhood of Hereford. The ground water certainly can not have had its source near Fort Bliss, as is proved by its artesian character. North of Hereford a point is reached at which the ground waters are very strongly alkaline, and it is evident that water can not have originated so far north. The contrast between the strong waters in the north and the soft waters in the southern part of the mesa suggests that the waters of the one portion of the mesa must be cut off geologically from those of the other part.

Within a few miles of the southern edge of the mesa several deep wells have been sunk to obtain water from the above-mentioned sand and gravel. Near the southern edge of the mesa the Southern Pacific Railroad has a group of wells designed to obtain ground water for railroad purposes. The wells are 8 inches in diameter and about 270 feet deep, and each contains at the bottom a No. 6 Cook strainer, 7 inches by 20 feet in dimensions. The quality of the water is excellent, but the quantity is very limited. The four wells, each supplied with a Downey double-acting deep-well pump, are able to secure no more than 150,000 gallons in twenty-four hours. About one-half mile north of the Southern Pacific wells two wells have been sunk to obtain water for the use of Fort Bliss Military Reservation. The two wells are about 20 feet apart, the depth of the eastern well being 313 feet and that of the western 319 feet. The wells have a diameter of 8 inches, contain 6-inch suction pipes, and carry at the bottom a No. 6 Cook strainer, 5¾ inches in diameter and 8 feet long.

They are pumped by two Cook deep-well pumps, which lift from 52,000 to 86,000 gallons in twenty-four hours. About 200 feet north of the military reservation at Fort Bliss the International Water Supply Company, of El Paso, Tex., has sunk seven 12-inch California stovepipe wells for the purpose of securing a municipal water supply for the city of El Paso. In one of these wells, which ended at the depth of 2,800 feet in a bed of dry clay, no water-bearing stratum was found below the sand referred to above. The yield of the International wells had not been determined, but it was evident from samples of material that it could not be much greater than that at the Southern Pacific or the military reservation wells. A yield of 100,000 gallons per twenty-four hours for each of the seven wells of the International Water Supply Company is probably a large estimate.

At the southern boundary of the mesa the Rio Grande is about 40 feet higher than the top of the water-bearing sand mentioned above (see fig. 5). There is every indication that at the time the river eroded the gorge above the city to the depth of 86 feet it also cut into this deposit of sand and resorted and redeposited the material, carrying away the finer portions. For this reason good wells can be had along the edge of the mesa wherever the river has done its work, except in a few places where the river has carried away all of the sand and left a local deposit of clay and mud. The water in the resorted gravels is very good, but not nearly as soft as the water of the wells on the mesa proper. In these resorted sands and gravels are located the wells used for irrigation in the bottom lands of the Rio Grande. The water found in the sands in the neighborhood of these pumping plants is probably in large part contributed by the Rio Grande. The accompanying table gives partial analyses of water taken from the mesa wells and from the wells in the bottom lands of the river. Furthermore, as shown by fig. 5, on the mesa the water plane slopes very gently toward the Rio Grande and near the irrigation pumping plants it slopes at a higher angle away from the river channel. As can be seen from fig. 5, the water planes on August 29, 1904, at the wells of W. N. French, about 3 miles east of El Paso, sloped away from the river at a gradient of 2 feet to the mile, while the slope from the mesa to French's well was two-thirds foot to the mile. On that date the water plane in the channel of the river stood about 2 feet lower than the surface of the stream. This indicates that the river probably does not furnish very much water to the sand on account of the deposits of silt in the river bed, except at times of flood, when the scour of the river extends to a considerable depth. At such times it is probable that the sands take up and store a considerable quantity of river water, which ultimately finds it way to the pumping plants.

Conditions similar to those mentioned were found about 8 miles east

of El Paso, at the pumping plants of J. A. Smith and J. S. Porcher. Fig. 7 shows the slope of the water plane between the river channel

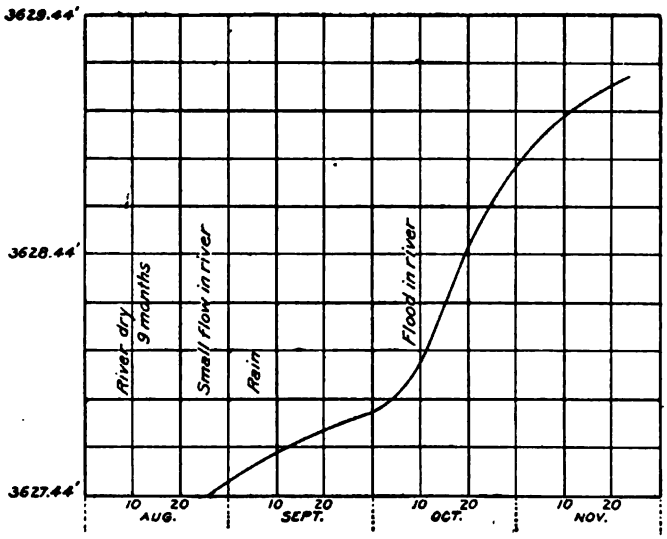



FIG. 6.—Elevation of water plane at Porcher's well No. 1.

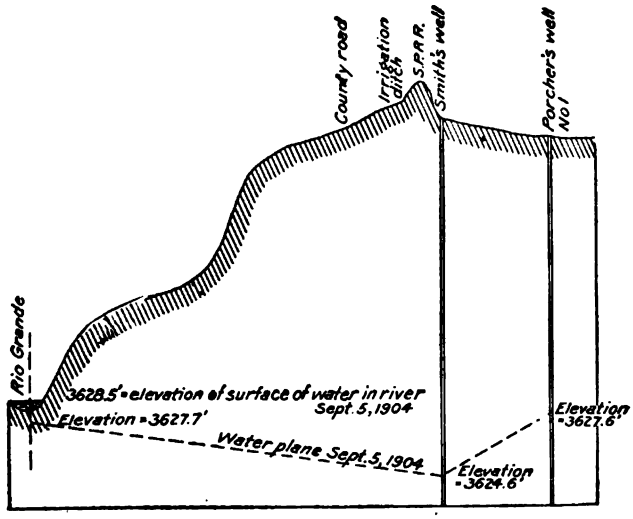



FIG. 7.—Water plane between Porcher's and Smith's pumping plants and the Rio Grande on September, 5, 1904.

and the wells of Smith and Porcher, as determined on September 5, 1904.

*Partial analyses of samples of water from the Rio Grande Valley, Texas and New Mexico.*

[In parts per 100,000.]

| Name of well. | Depth of well. | Total solids. | Chlorine. | Hardness as $CaCO_3$. | Alkalinity as $CaCO_3$. |
|---|---|---|---|---|---|
| Samples taken near El Paso, Tex.: | *Feet.* | | | | |
| City water, El Paso, Tex | ..... | 127 | 54.0 | 70.4 | 20.0 |
| El Paso Brewery | 58 | 72 | 21.4 | 30.0 | 21.2 |
| Felix Martinez | 68 | 62 | 13.7 | 29.6 | 19.1 |
| E. J. Hadlock | 30 | 104 | 31.5 | 47.7 | 27.7 |
| W. N. French | 78 | 55 | 11.0 | 25.0 | 17.7 |
| J. S. Porcher | 60 | 110 | 22.6 | 73.5 | 25.3 |
| J. A. Smith No. 1 | 62 | 174 | 55.6 | 67.0 | 23.0 |
| J. A. Smith No. 2 | 60 | 90 | 18.1 | 40.8 | 20.6 |
| Southern Pacific wells | 270 | 42 | 2.13 | 11.1 | 17.5 |
| Fort Bliss Military Reservation | 315 | 29 | 1.95 | 10.5 | 16.4 |
| El Paso and Northeastern at Fort Bliss | 250<br>410 | 46 | 2.38 | 11.3 | 20.0 |
| International Water Co | 260 | 22 | 1.48 | 7.25 | 11.5 |
| Samples taken near Berino, N. Mex.: | | | | | |
| Horaco Ranch Co. No. 2 | 53 | 126 | 30.9 | 45.8 | 29.6 |
| Horaco Ranch Co. No. 1 | 75 | 170 | 54.2 | 62.8 | 37.0 |
| Horaco Ranch Co. No. 3 | 62 | 203 | 63.9 | 59.5 | 52.5 |
| Samples taken near Las Cruces, N. Mex.: | | | | | |
| G. H. Totten | 62 | 99 | 19.6 | 59.8 | 29.5 |
| T. Roualt | 48 | 76 | 11.2 | 47.3 | 19.4 |
| W. N. Hager | 63 | 71 | 13.8 | 50.8 | 23.6 |
| A. L. Hines | 59 | 73 | 10.8 | 47.5 | 28.5 |
| F. C. Barker | 48 | 96 | 15.8 | 58.1 | 28.7 |
| Mrs. E. M. Boyer | 52 | 57 | 7.5 | 38.6 | 25.1 |
| J. C. Carrera | 58 | 83 | 11.2 | 54.2 | 27.3 |
| Samples taken at the gorge near El Paso: | | | | | |
| River water | ..... | 128 | 9.6 | 55.8 | 11.7 |
| Station No. 2 | 10 | 169 | 63 | 95 | 23.0 |
| Do | 22 | 400 | 137 | 100 | 18.6 |
| Station No. 3 | 29 | 589 | 213 | 139 | 20.9 |
| Test well No. 1 | 10 | 137 | 65.7 | 63.6 | 19.7 |
| Station No. 4 | 42 | 1,438 | 845 | 245.0 | 31.4 |
| Do | 60 | 4,600 | 1,033 | 224 | 35.9 |
| Station No. 5 | 50 | 2,500 | 1,040 | 224 | 31.4 |

*A.* SMALL RIG FOR DRILLING WELLS FOR STOCK.

*B.* TIMBER ON SACRAMENTO MOUNTAINS.

During nine months ending August 25, 1904, there was no water in the river channel below El Paso. During this time the water plane at the Porcher well No. 1 (an unused well 100 feet from the well of the new pumping plant) fell a total distance of 2 feet, or to an elevation of 3,627.44 above mean sea level. By September 5, 1904, after four days' rain the water in this well had risen 0.15 foot. The record of the week of rain is given in the table below. By October 2 the water plane had risen 0.37 foot (to 3,627.81 feet). On November 20, 1904, it was within 0.3 foot of the elevation before the 2-foot loss noted above, and was still rising at the rate of about one-fifth inch per 24 hours. On March 7, 1905, the water in the well had reached an elevation of 3,630.79, or a total rise of 3.35 feet in seven months. There was water in the Rio Grande during all of this period.

These observations show clearly that the principal source of the ground water near Smith's and Porcher's ranches is seepage from the Rio Grande. A heavy flood about October 9 greatly accelerated the rate of rise of the water plane, as is shown by fig. 6, where the changes in level at Porcher's well No. 1 are represented by a curve.

*Rainfall, in inches, at El Paso, Tex., September 1 to 10, 1904, as reported by the United States Weather Bureau.*

| | | | |
|---|---|---|---|
| September 1 | 0.0 | September 7 | 0.09 |
| September 2 | .09 | September 8 | Trace. |
| September 3 | .53 | September 9 | Trace. |
| September 4 | .62 | September 10 | .0 |
| September 5 | .16 | | |
| September 6 | .61 | Total | 2.10 |

# CHAPTER III.

## EXAMINATION OF GROUND-WATER SUPPLIES IN THE MESILLA VALLEY.

The valley of the Rio Grande begins to broaden north of the narrows in the neighborhood of El Paso, Tex. Near Las Cruces, N. Mex., the level bottom lands are about 5 miles wide, and irrigation has been extensively carried on for many years. Besides the city of Las Cruces, there are situated in this part of the valley the villages of Mesilla and Mesilla Park. Between old Fort Selden, north of Las Cruces, and the post-offices of Berino and Anthony, about 12,000 acres are under cultivation.

Owing to frequent shortage in the river supply of water, a number of pumping plants have been installed for the purpose of obtaining ground water for irrigation. One of the first wells for this purpose was drilled by the Agricultural College at Mesilla Park. At this place a coarse water-bearing gravel bed about 12 feet thick was found at a depth of 32 feet. This gravel is overlain by quicksand and adobe. The water level in the wells stood originally 16 feet below the surface of the ground. This well was used extensively for experimental purposes, and later a 12-inch well was put down to the same depth in the neighborhood of the 6-inch well. A great many tests of different kinds of pumps and engines were made at these wells, and a careful study was made of the cost of the recovery of the water, as well as of the amount of land in various kinds of crops that could be irrigated with the water recovered. A report on this work was published in 1903 by Professors Vernon and Lester and issued as a bulletin of the agricultural experiment station at Mesilla Park. As a result of the experiments and of the published reports on the wells at the agricultural station, a number of pumping plants have been installed during the present season, and many more are likely to be established in the near future. For that reason it has become important to have accurate information of the source of the ground-water supply in this part of the Rio Grande Valley and to determine the amount available for such use.

A reconnaissance near Las Cruces and Mesilla Park indicated that there is probably no underflow in this valley in the true sense in which that term is used. The rainfall upon the catchment area northeast of the valley is very slight and the run-off is correspondingly low. It

does not seem possible that the ground waters which are used for irrigation could originate very largely in the rainfall upon the neighboring mesa and the foothills and upon the slopes of the Organ Mountains

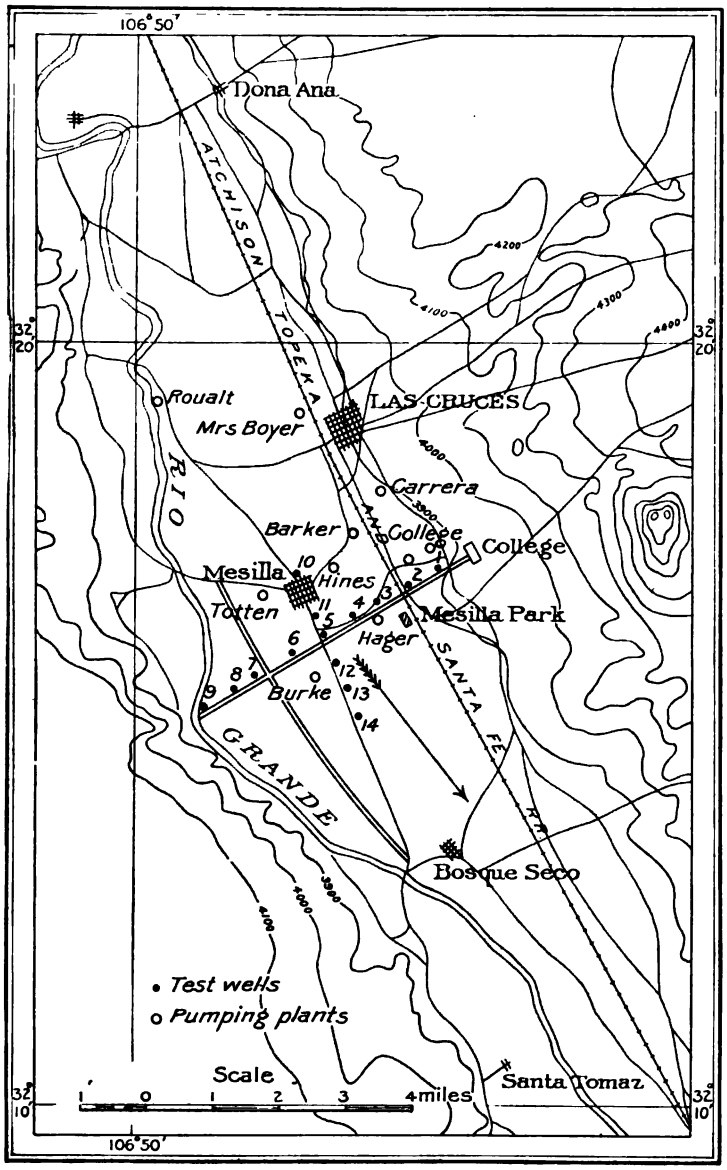



FIG. 8.—Map showing lines of test wells and location of pumping plants near Las Cruces and Mesilla Park, N. Mex.

to the northeast. These mountains are very precipitous, and furnish in all probability a very small amount of run-off to the ground waters of the valley.

## TEST WELLS.

For the purpose of determining the source of the ground waters in the Mesilla Valley two lines of test wells were sunk across the valley, one at right angles and the other parallel to the general direction of the river. These test wells were cased with 1½-inch pipe and were provided at the lower end with a common brass jacket well point. They were sunk to such a depth that the strainers would be completely covered with water at all times.

The plan of the test wells is shown in fig. 8. Across the valley are 9 wells on the average of one-half a mile apart. The wells were

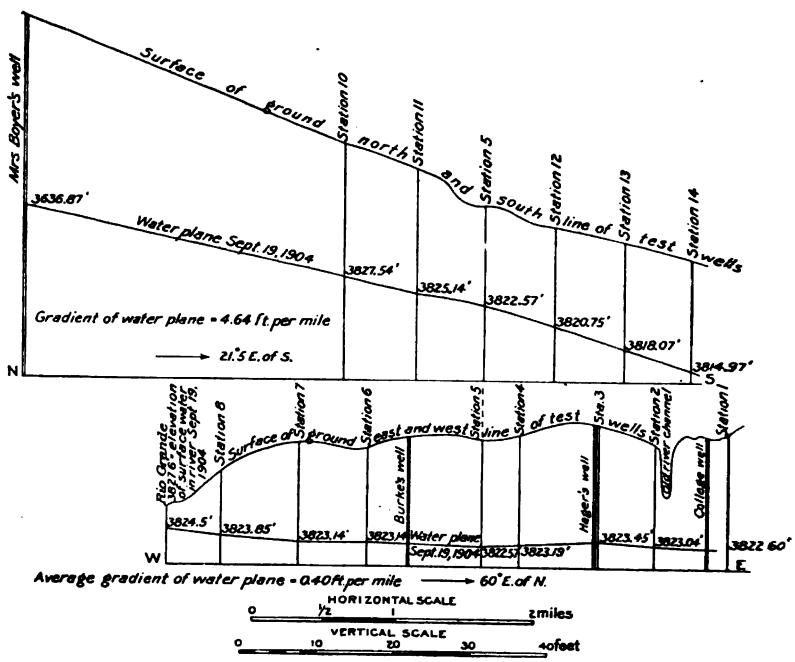



FIG. 9.—Position of the water plane September 19, 1904, in the two lines of test wells shown in fig. 8.

sunk as far as practicable along the public highways, so as to be readily accessible at all times. They were drilled primarily to determine the slope of the water plane in the valley and the changes in the position of the water plane during fluctuations in the level of the flowing water in the Rio Grande. In fig. 9 are shown the results of levels taken on both lines of test wells. In the upper part of the diagram is shown the position of the water plane September 19, 1904, in the wells of the north-south line. The Boyer well, located about 5 miles north of the northernmost 1½-inch test wells, was used as an additional test well, so as to extend the north-south line for a total distance of nearly 6 miles. As will be seen from fig. 9, the gradient of the water plane in the

direction of the north-south line of test wells averaged 4.64 feet per mile at the time of the first observation on September 19, 1904. As shown on the lower part of fig. 9 the water plane, in an east-west direction, was nearly horizontal, but near the river it was somewhat higher than at the east end of the line of test wells, although the surface slopes gently in the opposite direction. A slight elevation in this section is seen at station 3. On an average the water plane in the east-west cross section slopes about 0.4 foot per mile toward the east end. It is evident from these cross sections that the ground water must flow in the general direction of the river valley. The direction of maximum slope of the water plane is shown in fig. 8 by the large arrow. This arrow should, therefore, indicate the direction of flow of the ground water. The gradient of the water plane of 4.64 feet per mile is very moderate, and it is probable that the real velocity of the ground water is low. The slight elevation at station 3 indicates that at this point the ground water comes to some extent from the north, and does not move from east to west. If such an east-west movement took place the motion would be uphill for the entire distance from station 1 to station 3.

## SOURCE OF THE UNDERFLOW.

When the test wells were sunk it was expected that the position of the water plane in the wells would be observed every week until the time of high water in the Rio Grande, which would naturally be the spring of 1905. The test wells were sunk in cooperation with Prof. J. D. Tinsley, of the Agricultural College of New Mexico, who has made weekly observations of the height of the water plane in them. On October 5, 1904, heavy rains in the Rocky Mountains produced very disastrous floods in the Rio Grande and in nearly all the rivers heading in the Colorado Rocky Mountains. In the neighborhood of Las Cruces the maximum elevation of the river was higher than had been observed at any time in the last ten years. The period of very high water, so soon after the completion of the test wells, furnished an excellent opportunity of observing the effect of the floods in the Rio Grande upon the ground waters of the valley. Instead, therefore, of waiting for the spring floods of 1905, it became possible to determine immediately the essential facts in regard to the effect of the river upon the ground-water level. In Pl. IV the ground-water levels in the east-west line of test wells are given for each month from September 19 to March 26. The first observation taken on October 1 shows that the water had risen 0.4 foot since September 19. On October 9, however, the water at station 8 was 1.6 feet higher than on October 1. This was due to the flood of October 5. The flood raised the ground water at station 8 about 0.7 of a foot more during the next week, but from October 16 to 23 the small rise of 0.1 of a foot indicates that by October 23 the ground-water level at station 8 had tem-

porarily reached its highest position. Therefore, as a result of the flood, the gradient of the water plane immediately adjacent to the river, between stations 8 and 7, increased from 0.7 of a foot per mile to 2.3 feet per mile. The direction of movement of the water in the gravel was therefore undoubtedly downstream, even during times of flood, for while the east-west gradient increased to 2.3 feet to the mile in the immediate neighborhood of the river, the original downstream gradient of 4.64 feet to the mile was not materially affected. The test wells in the north-south line have not shown a departure of more than 0.1 of a foot from the original levels on September 19.

The table contains the observations on both sets of test wells until March 26, 1905. The Rio Grande had water in it continuously during this time. In high stages of the river the water in the wells still further rose, as is shown by the table and fig. 8. The total rise at station 8, located 0.4 mile from the river, was substantially 5 feet. The effect of the river can be traced at least 2 miles from its east bank. The rise at stations 1 and 2 during March, 1905, took place after irrigation had begun and is largely due to that cause.

*Elevation of ground water, in feet, above datum,[a] in east-west line of test wells near Mesilla Park, N. Mex.*

[Feet above datum.]

| Date. | No. 1. | No. 2. | No. 3. | No. 4. | No. 5. | No. 6. | No. 7. | No. 8. |
|---|---|---|---|---|---|---|---|---|
| 1904. | | | | | | | | |
| September 19 | 22.60 | 23.03 | 23.45 | 23.19 | 22.57 | 23.14 | 23.85 | 23.85 |
| October 1 | 22.61 | 23.10 | 23.43 | 23.15 | 22.85 | 23.19 | 23.16 | 24.25 |
| October 9 | 22.74 | 23.21 | 23.50 | 23.15 | 22.85 | 23.19 | 23.38 | 25.85 |
| October 16 | 22.77 | 23.23 | 23.48 | 23.13 | 22.86 | 23.14 | 23.59 | 26.18 |
| October 23 | 22.77 | 23.23 | 23.46 | 23.13 | 22.83 | 23.12 | 23.73 | 26.22 |
| October 30 | 22.77 | 23.21 | 23.42 | 23.13 | 22.86 | 23.07 | 23.81 | 26.28 |
| November 6 | 22.74 | 23.18 | 23.36 | 23.08 | 22.84 | 23.08 | 23.94 | 26.36 |
| November 13 | 22.77 | 23.20 | 23.36 | 23.09 | 22.86 | 23.10 | 24.05 | 26.38 |
| November 20 | 22.76 | 23.16 | 23.32 | 23.06 | 22.83 | 23.10 | 24.13 | 26.34 |
| November 27 | 22.77 | 23.18 | 23.34 | 23.03 | 22.83 | 23.11 | 24.18 | 26.42 |
| December 18 | 22.69 | 23.08 | 23.27 | 23.00 | 22.84 | 23.22 | 24.41 | 26.59 |
| 1905. | | | | | | | | |
| January 15 | 22.52 | 22.96 | 23.10 | 22.81 | 22.72 | 23.25 | 24.51 | 26.85 |
| February 5 | 22.50 | 22.96 | 23.05 | 22.79 | 22.74 | 23.48 | 24.66 | 26.78 |
| February 26 | 22.52 | 22.96 | 23.01 | 22.83 | 22.89 | 23.73 | 24.83 | 27.20 |
| March 12 | 22.98 | 23.06 | 23.01 | 22.95 | 23.01 | 23.82 | 25.10 | 28.20 |
| March 26 | 23.12 | 23.34 | 23.12 | 22.98 | 23.04 | 23.97 | 25.37 | 28.59 |

[a] Datum plane 3,800 feet above mean sea level.

U. S. GEOLOGICAL SURVEY

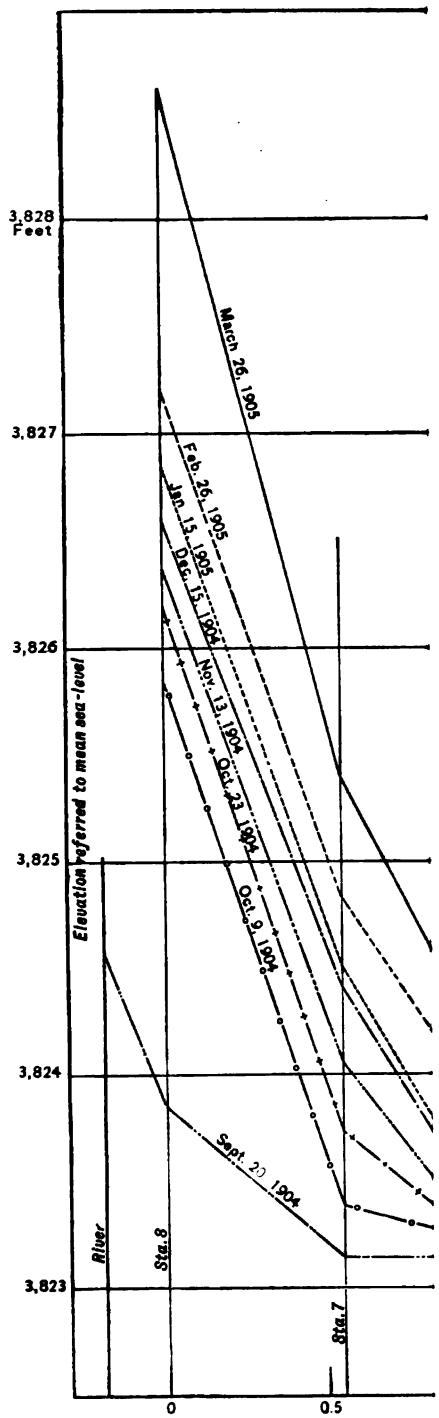



DIAGRAM SHOWING VARIAT
TEST WELL

*Elevation of ground water, in feet, above datum,*[a] *in north-south line of test wells near Mesilla Park, N. Mex.*

[Feet above datum.]

| Date. | No. 10. | No. 11. | No. 12. | No. 13. | No. 14. |
|---|---|---|---|---|---|
| 1904. | | | | | |
| September 20 | 27.54 | 25.14 | 20.75 | 18.07 | 14.96 |
| October 1 | 27.56 | 25.12 | 20.65 | 18.08 | 14.94 |
| October 9 | 27.68 | 25.11 | 20.71 | 18.16 | 15.01 |
| October 16 | 27.56 | 25.14 | 20.71 | 18.18 | 15.07 |
| October 23 | 27.52 | 25.12 | 20.70 | 18.16 | 15.09 |
| October 30 | 27.40 | 25.04 | 20.63 | 18.08 | 15.04 |
| November 6 | 27.46 | 25.07 | 20.65 | 18.11 | 15.11 |
| November 13 | 27.44 | 25.06 | 20.64 | 18.11 | 15.14 |
| November 20 | 27.43 | 25.03 | 20.63 | 18.10 | 15.16 |
| November 27 | 27.40 | 25.03 | ..... | ..... | ..... |
| December 18 | 27.40 | 25.03 | 20.64 | 18.14 | 15.29 |
| 1905. | | | | | |
| January 15 | 27.25 | 24.89 | 20.54 | 18.05 | 15.25 |
| February 5 | 27.29 | 24.91 | 20.54 | 18.18 | 15.29 |
| February 26 | 27.46 | 25.07 | 20.68 | 18.50 | 15.46 |
| March 12 | 27.59 | 25.16 | 20.83 | 18.59 | 15.59 |
| March 26 | 27.59 | 25.19 | 20.84 | 18.58 | 15.65 |

[a] Datum plane 3,800 feet above mean sea level.

The observations of the test wells show that the ground waters in the Mesilla Valley originate in the flood waters of the river. During times of low water the river bed is so thoroughly covered with mud that probably only a small amount of water escapes in the sand and gravels of the valley. During the period of flood, when the scour is deep, the contributions of the river to the underflow reach a maximum, as at that time the greatest amount of water is available for this purpose.

The observations of the ground-water level indicate also that a small portion of the underflow reaches the river valley from the mesa and foothills to the north and east of Las Cruces. The changes in the east-west line of water levels reached a maximum at the west end at station 8, with a secondary maximum at the east end at station 1. The high floods in the river were accompanied by rainfall on the mountains and mesa to the north and east of Las Cruces, and a sufficient amount of water penetrated the ground to cause the elevation of the water plane shown at the eastern end of the diagram. It will be observed that the total change in elevation at stations 1 and 2 was 0.2 of a foot. This change took place almost simultaneously with the rise at station 8.

Nevertheless, a slight indication of a lag in the rise of stations 1 and 2 can be observed from the diagram. The table on p. 26 gives the elevation of the water in the test wells as observed by Professor Tinsley between September 19, 1904, and March 26, 1905.

## INDICATIONS OF THE AMOUNT OF GROUND WATER AVAILABLE.

The following table gives the rate at which water was contributed to the underflow at Mesilla Park by the river, and also by the rainfall on the foothills and mountains northeast of the river valley. The total amount contributed by the river during the thirty-three days comprised in the period of observation was 8,900,000 cubic feet of water for each linear mile of the river valley. Of this amount 5,120,000 cubic feet, or more than half, was contributed in eight days, between October 1 and 9, which include the flood beginning October 5. In column 4 of the table is given the rate at which 1 linear mile of the river channel furnished water to the underflow, expressed as a continuous flow in cubic feet of water per second. These same facts are expressed in gallons per minute in column 5. The average rate of contribution for the 33-day period was 3.03 cubic feet per second, or 1,360 gallons a minute. If a plant which pumped continuously 1,360 gallons a minute was installed for each mile of the river valley, all the water contributed by the river would be pumped, and the level of the ground water at the end of the period would be the same as at the beginning. Any greater rate of pumping would have a tendency to lower the water plane below its initial value and make a draft upon the permanent supply stored in the gravels.

In columns 6, 7, and 8 is given the amount contributed to the underflow by the rainfall upon the mesa, northeast of the valley. The total amount contributed during the thirty-three days covered by the table was 1,517,000 cubic feet of water per mile of valley—an average flow of 0.515 cubic foot per second, or 232 gallons a minute. During the last week covered by the table the gravels near the eastern edge of the valley lost water instead of gaining, and the entries in the table for this period are negative. A well pump drawing 232 gallons of water per minute, if operated continuously during the 33-day period, would just consume the seepage from the rainfall contributed by 1 linear mile of the valley.

*Amount of water contribution to the underflow of the Rio Grande near Mesilla Park, N. Mex., between September 20 and October 23, 1904.*

| | | Amount of ground water contributed by each mile of the river. | | | Amount of ground water contributed by rainfall upon mesa east of the valley per mile of river valley. | | |
|---|---|---|---|---|---|---|---|
| 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. |
| Dates. | No. of days. | Cubic feet of water per 24 hours. | Cubic feet per second. | Gallons per minute. | Cubic feet of water per 24 hours. | Cubic feet per second. | Gallons per minute. |
| September 20 to October 1 | 11 | 110,500 | 1.28 | 575 | 40,500 | 0.47 | 211 |
| October 1 to 9[a] | 8 | 640,000 | 7.40 | 3,330 | 152,000 | 1.76 | 794 |
| October 9 to 16 | 7 | 248,000 | 2.87 | 1,290 | 29,900 | .35 | 155 |
| October 16 to 23 | 7 | 117,200 | 1.36 | 745 | 5,950 | .069 | 31 |
| Total | 33 | [b]8,900,000 | ..... | ..... | [b]1,517,000 | ..... | ..... |
| Average per day | ..... | 270,000 | 3.03 | 1,360 | 45,800 | .515 | 232 |

[a] Heavy flood on October 5, 1904.
[b] Total amount contributed for each mile of the valley in thirty-three days. Converting cubic feet into acre-feet we find that the river lost 204 acre-feet of water to the gravels of the underflow in thirty-three days, and 34.8 acre-feet were contributed by the rainfall in the same period. These amounts are for each mile of the valley.

## NECESSITY FOR DEEP WELLS.

The examination of the underflow of the Mesilla Valley was confined exclusively to the zone of ground waters, in which are all of the irrigation wells of the valley. These wells have a depth of from 48 to 63 feet, and contain no more than 12 linear feet of strainer at the bottom. In some cases quicksand or silt was encountered at the bottom of the water-bearing gravels, but in other cases the drill was stopped while still in good material. There are no deep wells in the valley, but there is no indication that good gravels will not be met with at greater depths than those known at present. There seems to be a reasonable expectation of increasing enormously the specific capacities of the wells, and consequently the amount of ground water available for irrigation by drilling wells to greater depths. There is great need of an experimental well several hundred feet in depth that will test satisfactorily the ultimate possibilities of ground-water supply.

## OBSERVATIONS AT BERINO, N. MEX.

Berino is situated in the Rio Grande Valley 15 miles south of Las Cruces. The ground water in this part of the valley lies for the most

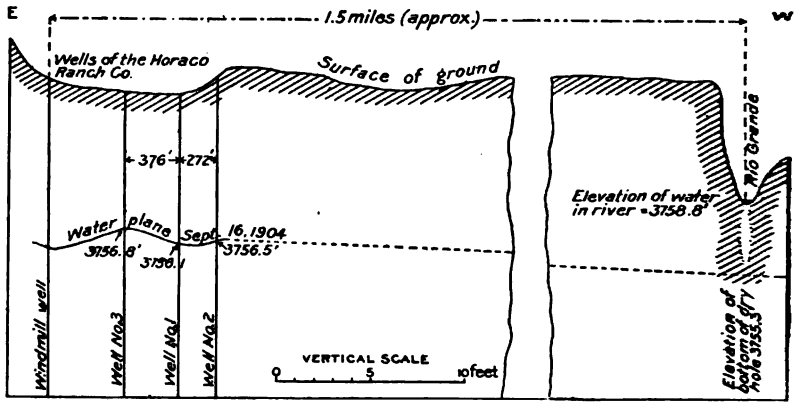



FIG. 10.—Cross section of part of Rio Grande Valley at Berino, N. Mex., showing position of the water plane on September 16, 1904. Water could not be found in a hole excavated 3½ feet below the level of running water at the edge of channel of the Rio Grande.

part within 8 or 9 feet of the surface. There is much "bosque," or lowland, which is covered with dense growth of timber, and in which the water plane is even nearer the surface.

A line of levels was run across the bottom lands of the valley at this point and the wells of the Horaco Ranch Company used to determine the position of the water plane. As shown on fig. 10, the water plane is nearly level in section A at right angles to the river valley, in which respect the situation at Mesilla Park is practically duplicated. A hole excavated to a depth of 3.47 feet below the surface of the running water in the river was dry at the bottom. The water plane is therefore some distance below the running water at low stages of the river, as at Mesilla Park and at points below El Paso. The losses of the river to the sands and gravels of its channel are undoubtedly small during low stages of water when the silt is heavily deposited. The principal contribution of the river to the underflow must take place during flood when the scour is deep.

In addition to the heavy autumn floods described above, very heavy floods came down the Rio Grande Valley during the spring of 1905. There was a good run of water during the entire winter. On this account the ground water at Berino in May, 1905, had risen about 4 feet above the level shown at the pumping plants in fig. 10.

# CHAPTER IV.

## SUMMARY OF TESTS OF PUMPING PLANTS IN SOUTHERN NEW MEXICO AND TRANS-PECOS TEXAS.

The table on pp. 34–35 shows the results of tests of a number of pumping plants used for irrigation in the valley of the Rio Grande in southern New Mexico and trans-Pecos Texas. Most of the headings in the table explain themselves. Under the heading "Location" is given the post-office nearest to the ranch on which the pumping plant is located. The first three pumping plants, those of Felix Martinez, W. N. French, and E. J. Hadlock, are located about 3 miles east of El Paso, Tex. The plants of J. A. Smith and J. S. Porcher are situated in the valley of the Rio Grande about 8 miles east of El Paso, Tex. The plants of Barker, Boyer, Burke, Carrera, Hager, Hines, Roualt, Totten, and the Agricultural College are located in the valley of the Rio Grande in the neighborhood of Las Cruces, N. Mex. The pumping plants of the Horaco Ranch Company are located near the post-office of Berino, N. Mex., which is situated 24 miles north of El Paso and 17 miles south of Las Cruces.

The fuel used in most of these pumping plants is gasoline, which term as here used includes the "distillate" manufactured from Texas crude oil, which is extensively used for fuel purposes. Its calorific value is somewhat less than that of the gasoline used in the Eastern States.

### DETERMINATION OF VACUUM.

In all of the plants, except the one of E. J. Hadlock, water is raised by means of centrifugal pumps, which are usually coupled directly to the top of the well casings. In order to determine the suction of the pumps it was necessary to drill a hole in the goose neck of the centrifugal pumps and insert the vacuum gage. The measurements to determine the distance the pumps were obliged to lift the water were made from this vacuum-gage tap as datum in all cases. In column 6 is given the distance the pump is required to lift the water above the vacuum-gage tap. In column 7 the vacuum reading is given in feet of water. The total lift of the pump can, therefore, be found in each case by adding the corresponding numbers in columns 6 and 7. In column 8 is given the distance that the water in the well is lowered during pumping. If the vacuum gage had been placed at the exact

level of the undisturbed ground water, the readings in column 8 would be identical to those in column 7. The numbers in column 8 are less than those in column 7, because in all cases the vacuum gage stood some distance above the natural level of the water in the well.

The vacuum gage was carefully calibrated against a mercury column at an altitude of 3,720 feet above mean sea level, and the corrected readings are tabulated in all cases. In cases in which there were no foot valves in the suction pipe, the depth of the well and the position of the water plane could be determined by sounding through the quarter-inch hole drilled for the vacuum gage.

### SPECIFIC CAPACITY.

The numbers in column 11 express the readiness with which the well furnishes water to the pump. In each case the result was obtained by dividing the numbers in column 10 by the corresponding numbers in column 8; column 11, therefore, expresses the amount of water the wells would furnish if the water level in them was lowered but one foot. These numbers constitute what is known as the "specific capacity" of the well, and are large in case of a good well and small in case of a poor well. This subject is more fully discussed in Water-Supply Paper No. 140, Chap. VII.

In column 12 are given the same magnitudes as in column 11, reduced in each case to 1 square foot of well strainer. The numbers in this column, therefore, express the amount of water in gallons per minute furnished by 1 square foot of well strainer under a head of 1 foot of water. They are a numerical expression of the degree of coarseness of the material in which the well is placed.

### COST AND OPERATING EXPENSES.

In column 13 are given the costs of the plants expressed in round numbers. They are nearly equivalent in most cases to $100 per horsepower for the total cost of engine, pump, and wells. In a few special cases the cost was higher. In estimating the expense of operation, an allowance of 10 per cent has been made for the depreciation and repairs and of 8 per cent for interest. It is difficult to make an accurate estimate of the proportion of cost that should be charged up to the water recovered by an irrigation plant, on account of the presence of several unknown factors. If the plants were in operation every day in the year it would be relatively easy to make an accurate estimate of these factors in the operating expense. As it is, the plants are in operation for a longer or shorter period, depending on circumstances which vary from year to year. Most of the plants are used merely as auxiliaries to the supply of ditch water. In making the estimate of the charge for interest and depreciation it has been assumed that the plants are in operation for two thousand hours each

season. This corresponds to a continuous use of three months of twenty-four hours daily, or two hundred days of ten hours each. It probably represents a fair average of the actual conditions.

In column 15 there is given a charge for labor and such other incidental expense—including oil and batteries—as is not properly included under the head of depreciation. The operation of the gasoline plants can be easily put in charge of unskilled labor, and for the smaller plants full time is not required of such labor.

## FUEL COST.

That part of the operating expenses which is properly chargeable to fuel cost can be accurately determined. Column 16 expresses the cost for fuel per hour. Column 18 expresses the cost per acre-foot of water recovered. In column 17 are given the costs of fuel for lifting 1,000 gallons of water through a distance of 1 foot. For the purpose of comparison these results are expressed in fractional parts of a cent.

In column 5 is given the price of fuel. The price of gasoline is given in cents per gallon in barrel lots. The price of electricity is given in cents per kilowatt hour. Cost of wood at the ranch of T. Roualt is that of cottonwood per cord. The price of wood at the Agricultural College of $2.25 per cord is the rate for small Tornillo wood, which has a higher calorific value than the cottonwood used by Roualt.

*Principal data derived from tests of Rio Grande pumping plants.*

| Name of plant. | Location. | Horse-power. | Fuel used. | Price of fuel. | Lift above vacuum. | Vacuum in feet of water. | Amount water is lowered. | Total lift. | Yield, gallons per minute. | Specific capacity. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | | | | | *Feet.* | | *Feet.* | *Feet.* | | *Gals. per min.* |
| Felix Martinez | El Paso, Tex | 10 | Electricity | $0.05 | 16.77 | 25.50 | 22.16 | 38.93 | 378 | 17.50 |
| W. N. French | do | 8 | Gasoline | .14 | 12.65 | 18.05 | 13.35 | 30.70 | 269 | 20.20 |
| E. J. Hadlock | do | 5½ | do | .14 | 5.20 | 22.60 | 13.03 | 27.80 | 258 | 19.80 |
| J. A. Smith No. 1 | do | 28 | Crude oil | .03 | 14.00 | 22.70 | 16.24 | 36.70 | 938 | 57.40 |
| J. A. Smith No. 2 | do | 22 | Gasoline | .14 | 15.45 | 26.10 | 21.00 | 41.45 | 1,325 | 63.20 |
| J. S. Porcher | do | 15 | do | .14 | 12.80 | 23.07 | 20.59 | 35.87 | 658 | 32.00 |
| F. C. Barker | Las Cruces, N. Mex | 5 | do | .17 | 20.18 | 25.40 | 22.48 | 45.58 | 131 | 5.83 |
| Mrs. E. M. Boyer | do | 12 | do | .17 | 17.60 | 22.70 | 19.76 | 40.30 | 658 | 33.30 |
| F. Burke | Mesilla, N. Mex | 21 | do | .17 | 14.85 | 25.60 | 22.85 | 40.45 | 725 | 31.75 |
| J. C. Carrera | Mesilla Park, N. Mex | 8 | do | .17 | 12.65 | 14.20 | 8.48 | 26.85 | 648 | 74.60 |
| W. N. Hager | do | 12 | do | .17 | 17.17 | 17.60 | 15.20 | 34.77 | 325 | 22.30 |
| A. L. Hines | Mesilla, N. Mex | 8 | do | .17 | 19.05 | 17.00 | 14.08 | 36.05 | 271 | 19.20 |
| T. Roualt | Las Cruces, N. Mex | 10 | Wood | 2.00 | 8.66 | 25.50 | 23.86 | 34.16 | 351 | 16.00 |
| G. H. Totten | Mesilla, N. Mex | 28 | Gasoline | .17 | 16.95 | 26.40 | 22.50 | 43.35 | 464 | 20.60 |
| Agricultural College | Mesilla Park, N. Mex | 20 | Wood | 2.25 | 17.10 | 12.45 | 11.37 | 29.55 | 1,000 | 88.00 |
| Horaco Ranch Company No. 1. | Berino, N. Mex | 12 | Gasoline | .17 | 9.71 | 14.18 | 13.75 | 23.89 | 837 | 60.80 |
| Horaco Ranch Company No. 2. | do | 12 | do | .17 | 10.36 | 24.90 | 23.64 | 35.26 | 191 | 8.10 |
| Horaco Ranch Company No. 3. | do | 12 | do | .17 | 11.56 | 20.80 | 18.55 | 32.36 | 750 | 40.40 |

*Principal data derived from tests of Rio Grande pumping plants*—Continued.

| Name of plant. | Location. | Horse-power. | Fuel used. | Specific capacity per square foot strainer. | Cost of plant. | Interest and depreciation. | Labor and other cost. | Fuel cost per hour. | Fuel cost 1,000 foot-gallons. | Fuel cost per acre-foot. | Total cost per acre-foot. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | | | | *Gals. per min.* | | *Per hour.* | *Per hour.* | | *Cents.* | | |
| Felix Martinez | El Paso, Tex | 10 | Electricity | 1.21 | $1,200 | $0.108 | $0.050 | $0.243 | 1/27 | $3.43 | $5.75 |
| W. N. French | do | 8 | Gasoline | 1.37 | 800 | .072 | .120 | .112 | 1/44 | 2.26 | 6.13 |
| E. J. Hadlock | do | 5½ | do | .792 | 800 | .072 | .140 | .074 | 1/58 | 1.58 | 6.02 |
| J. A. Smith No. 1 | do | 28 | Crude oil | 1.01 | 3,000 | .270 | .180 | .0975 | 1/171 | .70 | 3.17 |
| J. A. Smith No. 2 | do | 22 | Gasoline | 1.37 | 2,200 | .198 | .150 | .35 | 1/34 | 1.43 | 2.79 |
| J. S. Porcher | do | 15 | do | 1.28 | 1,500 | .135 | .150 | .21 | 1/67 | 1.73 | 4.10 |
| F. C. Barker | Las Cruces, N. Mex | 5 | do | .337 | 1,200 | .108 | .120 | .09 | 1/40 | 3.73 | 13.20 |
| Mrs. E. M. Boyer | do | 12 | do | 1.969 | 1,200 | .108 | .150 | .163 | 1/98 | 1.34 | 3.47 |
| F. Burke | Mesilla, N. Mex | 21 | do | .930 | 1,800 | .162 | .150 | .34 | 1/32 | 2.52 | 4.87 |
| J. C. Carrera | Mesilla Park, N. Mex | 8 | do | 3.530 | 900 | .081 | .120 | .177 | 1/59 | 1.48 | 3.16 |
| W. N. Hager | do | 12 | do | .760 | 1,200 | .108 | .150 | .31 | 1/22 | 5.14 | 9.57 |
| A. L. Hines | Mesilla, N. Mex | 8 | do | 1.790 | 800 | .072 | .120 | .255 | 1/23 | 5.10 | 8.95 |
| T. Roualt | Las Cruces, N. Mex | 10 | Wood | .62 | 1,200 | .108 | .180 | .223 | 1/32 | 3.47 | 7.91 |
| G. H. Totten | Mesilla, N. Mex | 28 | Gasoline | .760 | 2,000 | .180 | .150 | .37 | 1/33 | 4.34 | 8.19 |
| Agricultural College | Mesilla Park, N. Mex | 20 | Wood | 2.32 | 1,600 | .144 | .200 | .52 | 1/34 | 2.83 | 4.70 |
| Horaco Ranch Company No. 1. | Berino, N. Mex | 12 | Gasoline | 1.690 | 992 | .090 | .090 | .16 | 1/75 | 1.04 | 2.21 |
| Horaco Ranch Company No. 2. | do | 12 | do | .178 | 992 | .090 | .090 | .204 | 1/20 | 5.80 | 10.90 |
| Horaco Ranch Company No. 3. | do | 12 | do | .892 | 992 | .090 | .090 | .16 | 1/69 | 1.16 | 2.46 |

## COMMENTS ON THE RIO GRANDE PUMPING PLANTS.

The pumping plants of Martinez, French, Hadlock, Smith, and Porcher are all located in the bottom lands of the Rio Grande, from 3 to 8 miles east of El Paso, Tex. Column 12 of the table shows that the specific capacity per square foot of well strainer is nearly the same at the plants of Martinez, French, Smith No. 2, and Porcher, ranging from between 1.21 gallons a minute at Martinez's well to 1.37 gallons at French's well. These numbers, it should be remembered, represent the amount of water furnished by each square foot of well strainer for 1 foot head of water, and express, therefore, the degree of coarseness of the material in which the strainer is placed, provided, of course, that the well strainers themselves offer little or no resistance to the admission of water to the well. The specific capacity per square foot of strainer at the Smith plant No. 1 and at the Hadlock plant is much smaller than at the others. In the case of the Hadlock well, the low specific capacity is no doubt due to the fact that three of the Hadlock wells obtain water from above a clay which overlies the sand and gravel from which the fourth well and the neighboring wells of Martinez and French draw their supply. Furthermore, the strainers on the three Hadlock wells consist of nothing but common pipe perforated with round holes. This poor form of strainer is sufficient in itself to cut down very materially the specific capacity of the wells.

The low specific capacity at Smith's plant No. 1 is probably due chiefly to a local deposit of fine-sized water-bearing sand. There is no covering layer of clay over the water-bearing sands and gravels at these wells. The sands contain so little coarse material that fine sand is constantly being drawn into the wells by the pumps. This draft on the sand deposit at the easternmost of the three wells at Smith's plant No. 1 is so great that several wagon loads of gravel have been placed in the pit of the east well to replace the sand removed by the pumps.

The tests of the 9 wells in Rio Grande Valley near Las Cruces, N. Mex., form an interesting study. The relative locations of these 9 wells are shown in fig. 8. The rank of these wells in order of specific capacities per square foot of well strainer is as follows:

*Specific capacity, in gallons per minute, of wells near Las Cruces, N. Mex., per square foot of strainer.*

| | Gals. per min. |
|---|---|
| Carrera | 3.530 |
| Agricultural College | 2.320 |
| Mrs. Boyer | 1.969 |
| Hines | 1.790 |
| Burke | .930 |
| Hager | .760 |
| Totten | .760 |
| Roualt | .627 |
| Barker | .337 |

The first three of these wells are located near the eastern edge of the river valley, and their high specific capacity is undoubtedly due to coarse mountain débris that has been deposited along the eroded edge of the mesa. The high specific capacity at Hines's plant seems to be an exception to the general lower average prevailing in the intermediate district between the border of the mesa and the river channel, as at the plants of Hager, Totten, Burke, and Barker. The low specific capacity of the Barker well is due in part to its small diameter, and it is to be classed, therefore, with the Burke, Totten, and Hager wells rather than with the Roualt well. This last well is close to the river channel. Its low specific capacity is an indication of the progressive fineness of the deposits as the river is approached.

The specific capacities should be considered exceptionally high in the first wells in the above list, rather than exceptionally low in the others. Even the specific capacity of the Roualt well—over one-third of a gallon a minute per square foot of well strainer—would be regarded as high in many parts of the country.

The specific capacity of the three wells on the Horaco ranch near Berino, N. Mex., present an interesting study. These plants are located but a few hundred feet apart and are identical in all respects except in the depth of the wells. Nos. 2 and 3 are 9⅝ inches in diameter, and No. 1 is 7⅝ inches in diameter. Each has 18 linear feet of well strainer at the bottom, formed by drilling 1½-inch holes in the casing and wrapping the casing with No. 9 galvanized iron wire, leaving one-eighth inch space between. The enormous difference in the specific capacities of these wells is entirely due to the fact that No. 1 is 75 feet deep, No. 2 is 53 feet deep, and No. 3 is 62 feet deep. The small expense necessary to sink well No. 2 from a depth of 53 feet to a depth of 75 feet should change the cost of the water recovered from $10.90 per acre-foot to $2.21 per acre-foot.

Most of the pumping plants near Las Cruces have been very recently constructed, and changes will undoubtedly be made in many of them as the result of the experience of the present irrigation season. The wells at the Agricultural College were the first ones sunk in this part of the valley, and an excellent report on the tests of these wells, by Professors Vernon and Lester, was issued in April, 1903. The very high specific capacity of the college wells has influenced the construction of the other plants. With a few exceptions, it may be said that at the pumping plants in Mesilla Valley the engines and pumps are entirely too large for the wells, or the wells are too small for the pumps and engines. By comparing the high lifts recorded in column nine of the table with the amount of lowering of the water in the well, which is recorded in column eight, it will be seen that the lift of many of the plants can be considerably decreased by increasing the amount of strainer surface in the wells. In most cases this will make necessary

the sinking of additional wells, as the strainer surface can not be otherwise sufficiently increased. The necessity of keeping the lift of the pump down to a minimum is greatly emphasized in irrigation plants, and large strainer surface is the first requisite.

The efficiency of the smaller plants can also be increased by the construction of storage reservoirs or ponds for the accumulation of water before it is used for irrigation. In this way the duty of the water can be considerably increased. Barker's plant is the only one having such reservoirs. For plants that yield over a second-foot of water the reservoir is undoubtedly of little additional value.

The investigation showed that generally the speed of the centrifugal pumps had not been properly adjusted, and in nearly all cases was too high. This was undoubtedly due to the fact that the vacuum had never been determined, so that the total lift of the pumps was unknown. A table of observed and of correct speeds follows:

*Sizes and speeds (in revolutions per minute) of centrifugal pumps used in the Rio Grande pumping plants.*

| Name of plant. | Kind of pump. | Actual speed. | Correct speed. |
|---|---|---|---|
| Martinez | Byron Jackson No. 5 | 1,028 | 565 |
| French | Byron Jackson No. 4 | 938 | 890 |
| Smith No. 1 | Fairbanks Morse No. 6 | ..... | ..... |
| Smith No. 2 | Byron Jackson No. 7 | 585 | 592 |
| Porcher | Byron Jackson No. 5 | 712 | 629 |
| Barker | Byron Jackson No. 3 | 1,110 | 1,244 |
| Mrs. Boyer | Byron Jackson No. 5 | 730 | 665 |
| Burke | Byron Jackson No. 6 | 733 | 585 |
| Carrera | Byron Jackson No. 5 | 560 | 527 |
| Hager | do | 668 | 619 |
| Hines | Rumsey No. 4 | 594 | 558 |
| Roualt | Van Wie No. 3 | 525 | ..... |
| Totten | Byron Jackson No. 6 | 692 | 606 |
| Horaco No. 1 | Byron Jackson No. 5 | 695 | 513 |
| Horaco No. 2 | do | 700 | 624 |
| Horaco No. 3 | do | 692 | 598 |

# CHAPTER V.

## DETAILS OF TESTS OF PUMPING PLANTS.

The following pages contain detailed accounts with diagrams of the various pumping plants discussed in general terms in the preceding chapter of this report. The location of the various plants is marked in figs. 4 and 8.

### PLANTS NEAR EL PASO, TEX.

#### PLANT OF E. J. HADLOCK.

The plant of E. J. Hadlock is located near the main country road near El Paso, Tex., about 400 feet east of the pumping plant of Felix Martinez. Water is pumped by a 5½-horsepower horizontal Otto gasoline engine geared to a horizontal double-acting piston pump. The wells consist of four 4-inch wells, arranged as shown in figs. 11 and 12. Three of the wells, Nos. 1, 2, and 3 in fig. 10, draw surface water from

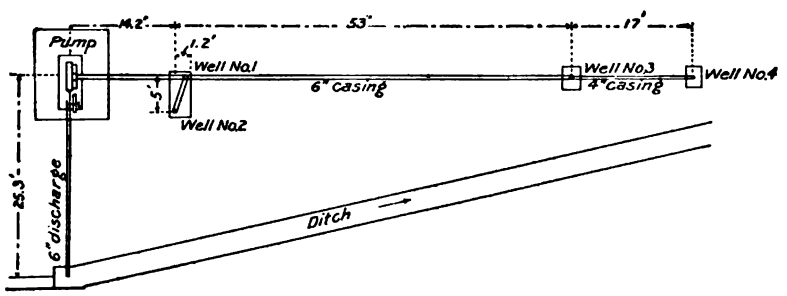



FIG. 11.—Plan showing arrangement of wells at Hadlock's pumping plant.

above a clay stratum. The fourth well, which is 54.35 feet deep and penetrates the surface water and clay, obtains very good water from a deposit of sand and gravel below the clay.

Wells Nos. 1, 2, and 3 are about 30 feet deep. Each of these has 6 feet of perforated iron pipe on the bottom, while well No. 4 has a 6-foot strainer constructed of perforated galvanized iron. During the test the engine made 210 revolutions and 81 explosions per minute. The pump made 69 strokes per minute. The vacuum gage attached to the suction pipe fluctuated very erratically, showing that the pump

valves were badly worn. One end of the pump seemed to be working very well and showed a vacuum of 22 inches, which is equivalent, when corrected for altitude, to 20 inches of mercury or 22.6 feet of water. The lift of the pump above the vacuum gage was 5.2 feet, making a total lift of 27.8 feet. The distance from the vacuum-gage tap to the water plane was 9.75 feet. The water in the well was lowered 13.03 feet during pumping.

The discharge of the pump was determined by means of a fully contracted weir, which was placed in the main irrigating ditch. The width of the crest was 1.01 feet, height of water on the crest was 0.313 feet, and the discharge was 258 gallons per minute. The pump cylinders were 9½ by 14 inches. With the speed noted above the pump should discharge, if no allowance be made for slip, 507 gallons per minute. It is seen that the slip of the pump was 49 per cent, which shows that the valves at one end of the pump were doing practically no work at all.

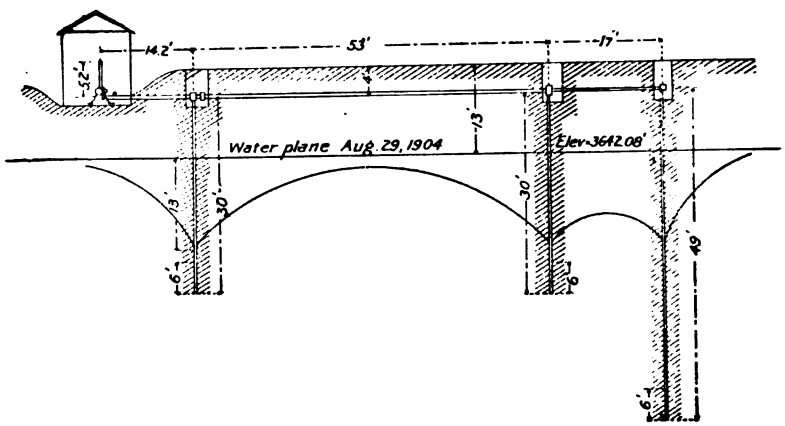



FIG. 12.—Elevation of wells at Hadlock's pumping plant near El Paso, Tex.

At well No. 4 the elevation above mean sea level of the water plane on August 29, 1904, was 3,642.08 feet, that of the top of tee on casing of this well and of the vacuum-gage tap was 3,651.652 feet, and that of the surface was 3,656 feet.

From the discharge (258 gallons per minute) and the amount that the water level in the well was lowered during pumping (13.03 feet), it is estimated that the specific capacity of the group of four wells is 19.8 gallons per minute. As the combined area of well-strainer surface in all of the wells is 25 square feet, the specific capacity per square foot of strainer is 0.792 gallons per minute.

At the time of the test, on August 16, 1904, the Hadlock pumping plant had been in continuous operation day and night for several

months. The quantity of gasoline used was determined from the amount required to fill the tank to standard depth after one hour's run. As 2.1 quarts of gasoline were consumed per hour, the hourly cost for fuel, with gasoline at 14 cents per gallon, is $0.0735. The yield of water in one hour was 15,500 gallons, so that the fuel cost was $0.00475 per 1,000 gallons, $1.58 per acre-foot, and $0.000171, or one fifty-eighth of a cent per 1,000 foot-gallons (1,000 gallons raised one foot).

### PLANT OF W. N. FRENCH.

At the pumping plant of W. N. French (see fig. 13) water is obtained from an 8-inch well, 66 feet deep, which has a 7-inch by 8-foot perforated galvanized iron strainer at the bottom. The water is raised by a No. 4 Byron Jackson horizontal-shaft centrifugal pump driven by a 10-horsepower Charter gasoline engine. The engine made 189 revolutions and 95 explosions a minute, no explosions being missed. The diameter of the driven pulley on the pump was 6 inches; that of the driving pulley on the engine was 30 inches. The speed of the pump was 938 revolutions a minute. The top of flange on the well casing is 12.65 feet below the top of the 5-inch discharge pipe, which rises from the pump at an angle of 45°. Before pumping, the water stood 4.7 feet below top of flange on the well casing. After one-half hour's pumping it was 18.05 feet below top of flange, showing that it was lowered 13.35 feet by pumping. The lift of the pump above the top flange of the well was 12.65 feet, making a total lift of 30.70 feet. The elevation of the water plane in the French well on August 29, 1904, was 3,642.969 feet; on September 8, after several days of rain, it was 3,643.07 feet. Between August 29 and September 8 it rained every day, and the neighboring pumping plant of Mr. Hadlock had not been in use. The elevation of the top of the delivery pipe at the French well was 3,658.884 feet.

The discharge was measured both by integrating with a Price acoustic current meter in a rectangular flume and by means of a fully contracted weir placed in the main ditch not far from the pumping plant. The cross section selected for the meter measurement had an average depth of 0.857 foot, an average width of 0.885 foot, and an area of 0.76 square foot. The average velocity of the water was 0.82 foot per second, giving a discharge of 0.596 second-foot, or 269 gallons, per minute.

The same discharge was also measured by a fully contracted weir. The length of the crest was 1.01 feet and the height of the water on the crest was 0.30 foot. The velocity of approach was about one-half foot per second. Using the weir formula,

$$q = c.\tfrac{2}{3}\sqrt{2g}\, b\,(H + 1.4h)^{3/2}$$

and substituting the coefficient 0.608 for the number $c$ in the formula (Table 23, Merriman's Hydraulics, 1903) we obtain,

$$q=0.608 \times \tfrac{2}{3} \times 8.025 \times 1.01\ (3.06)^{3/2}$$
$$=0.555 \text{ second-foot}$$
$$=250 \text{ gallons per minute.}$$

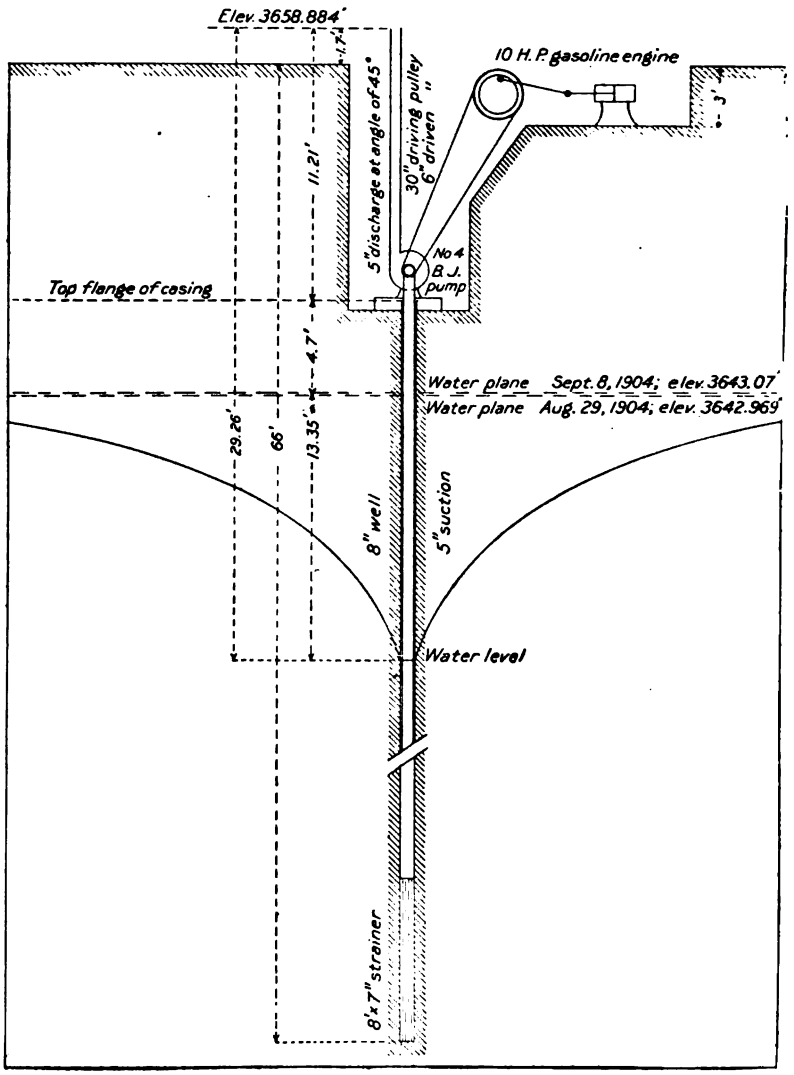



FIG. 13.—Diagram of pumping plant of W. N. French, near El Paso, Tex.

The discharge as determined by the current meter has been used in the following estimates:

The specific capacity of the well is 20.2 gallons a minute. As the strainer has an area of 14.7 square feet, the specific capacity for each square foot of strainer is 1.375 gallons per minute.

In the French test 8 gallons of gasoline were used in ten hours. With gasoline at 14 cents per gallon the cost of fuel is 11.2 cents per hour. As 16,150 gallons of water were obtained in one hour the fuel cost per 1,000 gallons was $0.00695, or $2.26 per acre-foot. The total lift being 30.7 feet the cost per 1,000 foot-gallons was $0.000226, or one forty-fourth of a cent.

### PLANT OF FELIX MARTINEZ.

The plant of Felix Martinez is located about 3 miles east of the court-house of El Paso, Tex., near the main country road (see fig. 4). It consists of a No. 5 Byron Jackson horizontal-shaft centrifugal pump run by General Electric 10-horsepower direct-current motor, type C. E., class 4. The pump is located in a pit and is connected to a 6-inch well. The well is 68 feet deep and has 10 feet of perforated or slotted galvanized iron strainer at the bottom. The gravels, which were reached at a depth of 56 feet are fairly large, but contain a great quantity of fine sand. The pump is connected with the well by a 5-inch suction pipe and discharges through a vertical and horizontal 5-inch pipe into a rectangular flume. The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The cross section of flume where measurements were taken had an average depth of 0.475 foot, an average width of 0.992 foot, and an area of 0.470 foot. The mean velocity was 1.78 feet per second, giving a total discharge of 0.838 cubic foot per second, or 378 gallons per minute.

The vacuum gage was attached to the goose neck of the centrifugal pump. After a few minutes pumping the vacuum was 18 inches, but it gradually fell to 24½ inches at the close of the first half hour, where it remained constant during the next hour. The vacuum, when corrected for altitude, is equivalent to 22.5 inches of mercury, or 25.5 feet of water.

On August 29, 1904, the elevation above sea level of the water plane was 3,643.13 feet; that of the vacuum-gage tap was 3,646.47 feet, and that of the top of discharge pipe was 3,659.90 feet. As the water level in the well was lowered 22.15 feet by pumping, the total lift was, therefore, 38.93 feet. The specific capacity of the well is 17.5 gallons per minute. As the area of the well strainer is 14.4 square feet, the specific capacity for each square foot of well screen was 1.21 gallons per minute.

The amount of electric current used during the pumping was determined by means of a Westinghouse watt meter. The current used in one hour's test (average speed of motor 1,485 revolutions a

minute) was 4,950 watts. Speed of the pump was 1,028 revolutions a minute. The diameters of the pulleys are as follows: Pulley on motor, 7½ inches; driven pulley on countershaft, 24 inches; driving pulley on countershaft, 14 inches; pulley on pump shaft, 6 inches.

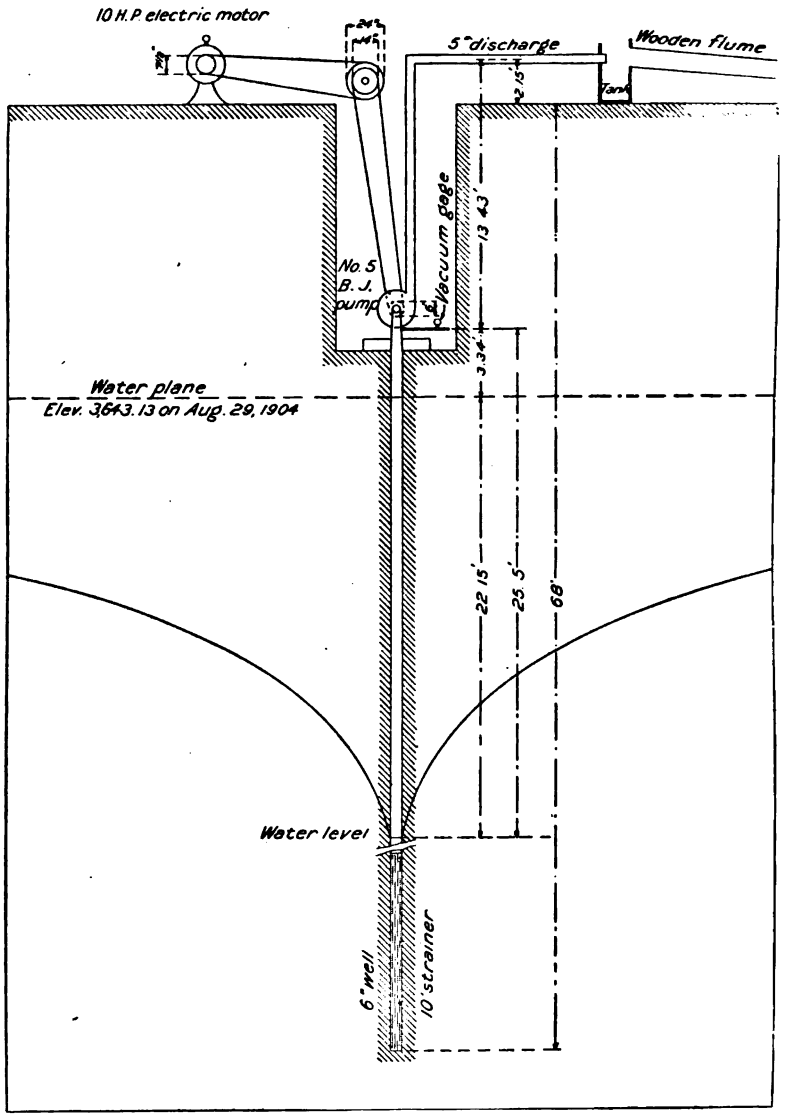



FIG. 14.—Diagram of pumping plant of Felix Martinez, near El Paso, Tex.

The power actually used at the plant is the equivalent of 4,950 watts, or 6.64 horsepower. The power represented by the discharge of 0.838 second-feet of water lifted 38.93 feet is equivalent to 2,030 foot-

pounds per second, which is equal to 3.7 effective horsepower. If the applied horsepower, 6.64, is compared with the effective horsepower, 3.7, the total efficiency of the plant is found to be 55.5 per cent. The duty of the plant can be found by comparing 4,950 watts, the electrical energy consumed in one hour, with 655,200 foot-gallons, the work done by the pump in one hour. The resulting duty is 132,400 foot-gallons of water per kilowatt hour of electric current.

### PLANTS OF J. A. SMITH.

The plants of J. A. Smith are located 8 miles east of El Paso, Tex., near the right of way of the Southern Pacific Railroad. There

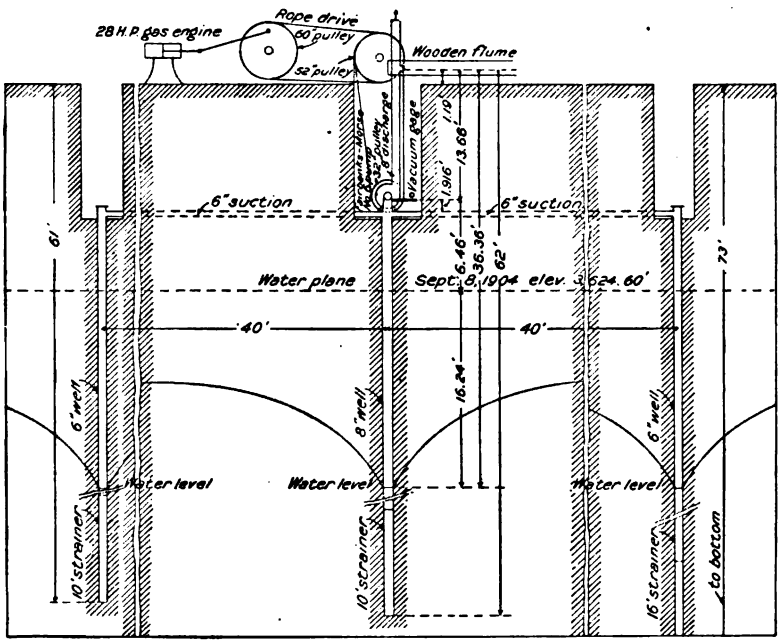



FIG. 15.—Diagram of J. A. Smith's pumping plant No. 1, near El Paso, Tex.

are two pumping plants on the same ranch. At the first or older plant there are three wells, 40 feet apart, in a row. The pump pit is over the middle well, which is 8 inches in diameter and 62 feet deep, measured from the surface. Fine sand and quicksand were passed through to a depth of 50 feet, then 12 feet of coarse gravel containing much fine material was encountered. A 10-foot slotted galvanized-iron strainer of the Porcher pattern was placed at the bottom of this well. The east well is 6 inches in diameter and 73 feet deep. The gravel at this point is 22 feet deep. A 16-foot Porcher strainer was used. The west well is 6 inches in diameter and 61 feet deep. The gravel was 11 feet deep, and a 10-foot Porcher strainer was used. All

of the strainers have $\frac{3}{16}$ by $1\frac{1}{2}$ inch slots or perforations. The horizontal 8-inch suction pipe, which extends from the central well to the east and west wells, is 14 feet below the surface.

The water is pumped by a No. 6 Fairbanks-Morse horizontal-shaft centrifugal pump, connected with rope drive to a 28-horsepower gasoline engine, with crude-oil gas generator attached. The fact that the engine is supplied with gas generated from Texas crude petroleum renders this plant of especial interest. For the amount of water obtained the fuel cost is the lowest I have seen recorded for a small plant. The attached gas generator has been in operation several months, running continuously day and night, except when stopped for cleaning each week or two. When the generator is kept clean there is little trouble from carbon passing from the generator into the cylinder of the engine and cutting out the cylinder and packing. This plant is a decided success, as the further account to be given will show. The engine made 159 and the pump 544 revolutions per minute.

The discharge was measured by integrating with a Price acoustic current meter in a rectangular flume. The selected cross section had an average depth of 0.53 foot, an average width of 1.87 feet, and an effective area of 0.992 square foot. The average velocity was 2.085 feet per second, giving a discharge of 2.075 second-feet, or 934 gallons per minute. This measurement of discharge was made after three months of continuous pumping day and night. The elevation of the vacuum-gage tap, which was 0.917 foot above the top of horizontal suction pipe, was 3,631.06 feet; that of the water plane on September 8, 1904, was 3,624.60 feet, and that of the middle of the 8-inch opening in the tee in the side of vertical discharge pipe, from which the water enters a horizontal wooden flume, was 3,645.06 feet. The vacuum read 22 inches, which, when corrected for altitude, is equivalent to 20 inches of mercury, or 22.7 feet of water. The total lift is, therefore, 36.7 feet. The water is lowered in the wells 16.24 feet by pumping, which gives a specific capacity for the three wells of 57.4 gallons per minute. As the total area of the strainers in all of the wells is 56.7 square feet, the specific capacity for each square foot of strainer is 1.01 gallons per minute.

Several accurate tests have been made of the amount of fuel consumed at this plant. One test was made by the manufacturers of the gas generator, and consequently the consumption of crude oil appears at a minimum. This test lasted seventy-four hours and fifteen minutes. The amount of crude oil consumed was 241 gallons, or 3.24 gallons per hour. With oil at 3 cents per gallon, the cost of fuel will be $2.34 per day of twenty-four hours. The cost of water was, therefore, $1\frac{3}{4}$ mills, or ten fifty-sevenths of a cent per 1,000 gallons, or 57 cents per acre-foot. The lift being 36.7 feet, the cost of 1,000 foot-gallons was one two hundred and tenth of a cent.

Another experimental test of the plant was made when the engine was in charge of the regular help employed on the ranch. No effort was made to save oil or make a record, everything being managed exactly as it was during several months of pumping for irrigation. The test was for forty and one-half hours, extending over four consecutive days of about ten working hours each. The amount of crude oil used was 163.5 gallons, or 97 gallons per twenty-four hours, or 4.03 gallons per hour. This represents, therefore, the actual rate at which oil was consumed during the irrigation season. The cost of fuel is $2.90 per twenty-four hours, 12 cents per hour, ten forty-sixths of a cent per 1,000 gallons, and one one hundred and seventy-first of a cent per 1,000 foot-gallons.

The cost of the water at the same plant, when pumped with gasoline, was also determined. In a test of eleven hours' run with same engine, using gasoline instead of crude oil gas, 40 gallons of gasoline were consumed, or 3.64 gallons per hour. At 14 cents per gallon, the hourly cost for gasoline was $0.51. This makes the fuel cost of water $0.0092 per 1,000 gallons and $0.000236, or one forty-second of a cent per 1,000 foot-gallons.

The above estimates do not represent, of course, the total cost of pumping, as no items have been included to cover interest, depreciation, labor, etc.

The 934 gallons per minute furnished by the above plant amounts to a little over 2 second-feet, or 4 feet per twenty-four hours. The cost of fuel per acre-foot of water was, therefore, 70 cents when using crude oil and $2.95 when using gasoline costing 14 cents a gallon.

J. A. Smith's pumping plant No. 2 is about 1,000 feet north of plant No. 1, which is on the same ranch. There are two 8-inch wells, 40 feet apart, in an east-west line. Each one is 60 feet deep and is equipped with 12 feet of Porcher slotted galvanized iron strainer. The gravel bed is 12 feet thick and is overlain by a thick deposit of clay and hardpan. A No. 7 vertical shaft Byron Jackson centrifugal pump is connected to an 8-inch horizontal suction pipe that is 12.25 feet below surface. The pump is 7 feet from the east well and 33 feet from the west well. It was driven at a speed of 585 revolutions per minute by a 22-horsepower Fairbanks-Morse gasoline engine. The engine made 195 revolutions per minute, the engine being belted to the pump shaft from 36-inch driving pulley to 12-inch driven pulley. The vacuum shown at center of the suction pipe was 25 inches, or 23 inches of mercury when corrected for altitude, corresponding to 26.1 feet of water. The vacuum-gage tap is 14.85 feet below the top of the discharge pipe, above which the discharge jet rises 0.6 foot, so that the total lift is 41.45 feet. A vertical 10-inch pipe delivers the water into a nearly horizontal rectangular flume in which the discharge was meas-

ured by integrating with a Price acoustic current meter. The discharge was determined to be 2.945 second-feet, or 1,325 gallons, per minute. As the water in the wells was lowered 21 feet below the

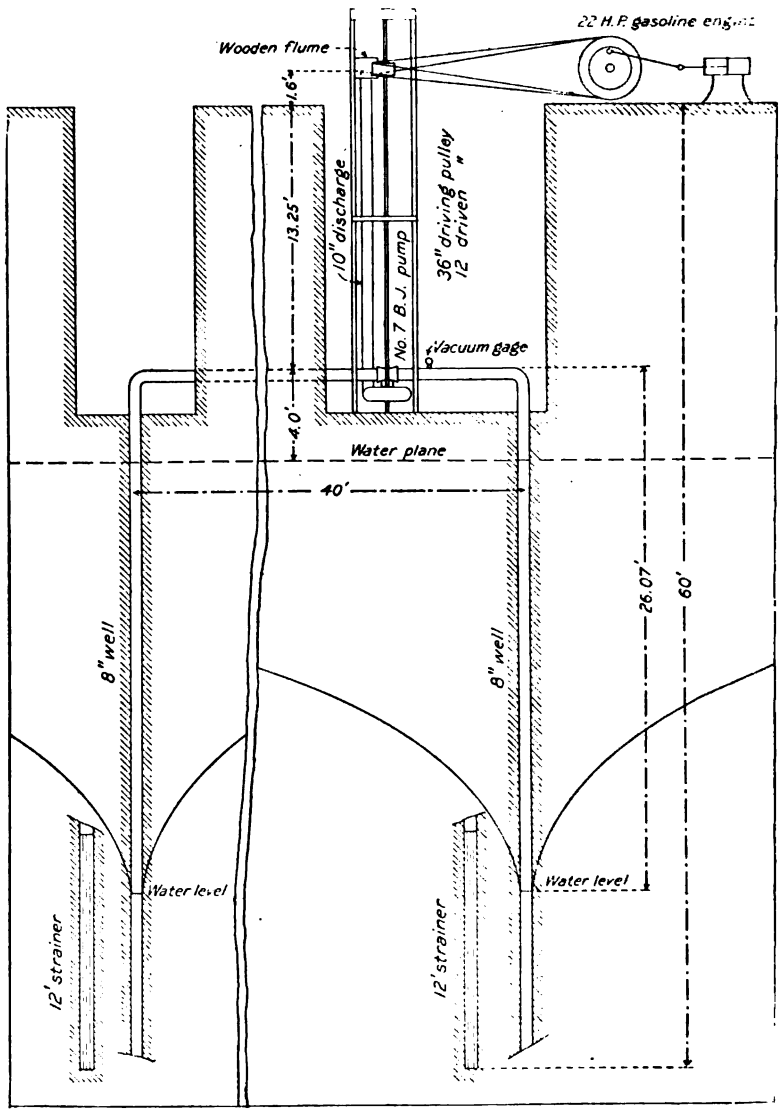



FIG. 16.—Diagram of J. A. Smith's pumping plant No. 2, near El Paso, Tex.

normal water plane by the pumps, the specific capacity of the two wells was 63.2 gallons per minute, or since the total strainer surface is 46 square feet, 1.37 gallons per minute for each square foot of strainer.

The expense of pumping at this plant can readily be estimated as far as the cost of fuel is concerned. The engine, as run in the above test, consumed per hour 2.5 gallons of gasoline or distillate, costing 14 cents per gallon. The fuel cost is, therefore, 35 cents per hour, 0.44 cent per 1,000 gallons, $0.000106, or one ninety-fourth of a cent, per 1,000 foot-gallons, and $1.43 per acre-foot.

### PLANT OF J. S. PORCHER.

This pumping plant is located on the ranch of J. S. Porcher, in the Rio Grande Valley, about 8 miles east of El Paso, Tex., and about 1,000 feet east of J. A. Smith's first wells. Water is obtained from a well 8¼ inches in diameter and 60 feet deep. The water-bearing gravel has a thickness of 12½ feet and lies below a layer of quicksand. There is a 12-foot slotted galvanized iron strainer at the bottom of the well. Mr. Porcher first used this type of strainer in the Rio Grande Valley. At the present time this form of strainer is universally used, and is known as the "Porcher" strainer (see Pl. II, *B*). Water is raised by a No. 5 Byron Jackson horizontal-shaft centrifugal pump driven by a 15-horsepower Columbus gasoline engine. The engine made 212 revolutions and 75 explosions per minute. The diameter of driving pulley was 30 inches and that of driven pulley 8 inches. The pump made 712 revolutions per minute. The water is discharged through an 8-inch vertical pipe into a rectangular wooden flume. The discharge from this rectangular flume was measured by integrating with a Price acoustic current meter. The selected cross section had an average depth of 0.1792 foot, a width of 1.92 feet, and an area of 0.344 square foot. The current meter showed that the average velocity was 4.245 feet per second, which gives a discharge of 1.46 second-feet, or 658 gallons per minute. The vacuum gage read 22.4 inches, which, when corrected for altitude, is equivalent to 20.4 inches of mercury, or 23.07 feet of water. The elevation of the ground water at the well on September 5, 1904, was 3,627.59 feet and that of the vacuum-gage tap was 3,630.07 feet, so that the water in the well was lowered 20.59 feet by pumping. As the vacuum-gage tap is 12.8 feet below the top of the discharge pipe the total lift is 35.87 feet.

Since the water level in the well was lowered 20.59 feet, the specific capacity of the well is estimated to be 32 gallons per minute, or 1.28 gallons per minute for each square foot of strainer.

The amount of gasoline used in running the engine was determined in two test runs. During the first test the consumption of gasoline from 6 a. m. to 4 p. m. was ascertained by measurements in the gasoline reservoir. In the ten hours' test there was used 14.3 gallons, or 1.43 gallons per hour. In the second test Mr. Porcher determined the time necessary to consume 5 gallons of gasoline in the engine. At 6.30 a. m. on the day of the test 5 gallons of gasoline were placed in the empty

gasoline reservoir. All the gasoline had been used up by 10.20 a. m., so that the consumption was 5 gallons in 3.83 hours, or 1.31 gallons per hour. As the engine was run with considerable care during these

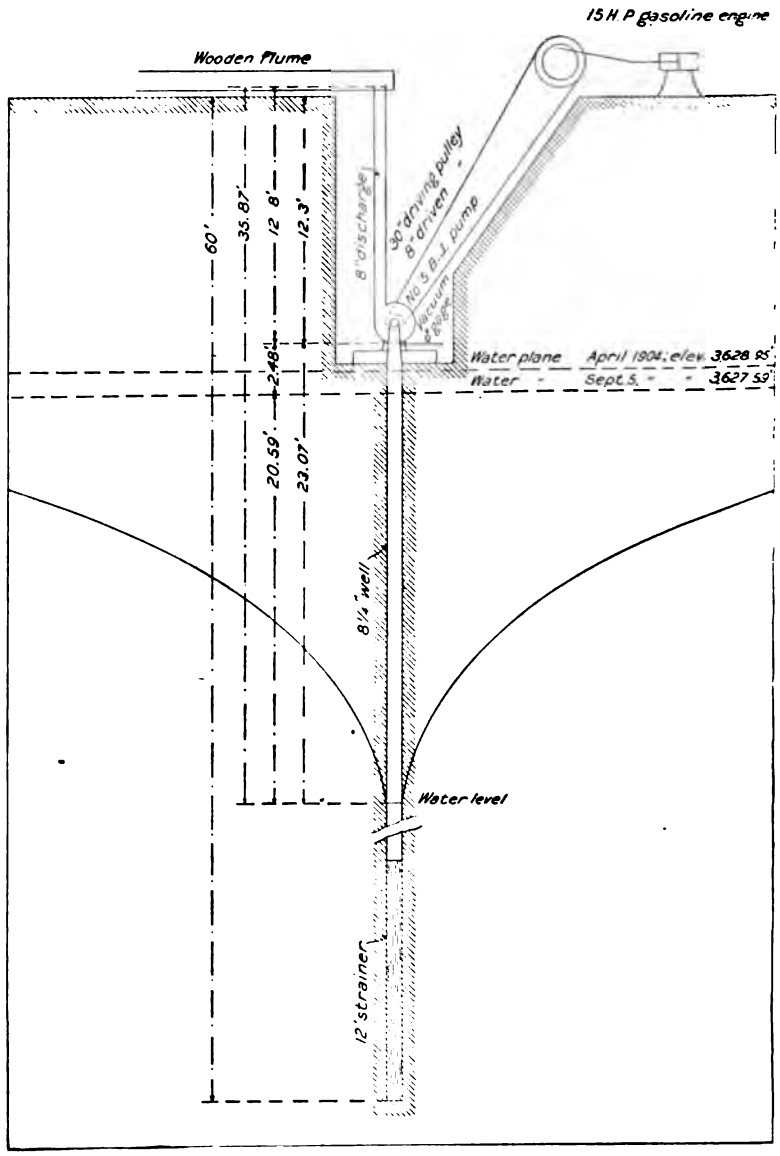



FIG. 17.—Diagram of pumping plant of J. S. Porcher, near El Paso, Tex.

tests, it is probable that the consumption of gasoline normally runs as high as 15 gallons for ten hours. The hourly cost for fuel, with gasoline at 14 cents per gallon, was 21 cents. As 39,500 gallons of water

were obtained in one hour, the cost was $0.00531 per 1,000 gallons, $1.73 per acre-foot, and $0.0001, or one sixty-seventh of a cent, per 1,000 foot-gallons.

A 4½-acre field of alfalfa can be irrigated with the pump in from fourteen to nineteen hours. After a rain it was irrigated in fourteen hours, but sixteen hours usually are required. A number of irrigations of the same field have varied from sixteen to eighteen hours each. This field was irrigated every seven days, and the crop taken off at the end of the fourth week, so there were three irrigations to a crop.

With gasoline, or distillate, at 14 cents per gallon, or $2.36 per acre, per crop of alfalfa (three irrigations), the crop cut from the field averaged fully a ton to an acre, and at the selling price of $12 to $14 per ton, the irrigation with the pump could be carried on at a good profit. If the selling price had been as low as $7 per ton there would be no profit in the irrigation of alfalfa by pumping.

## TESTS OF PUMPING PLANTS IN MESILLA VALLEY, NEW MEXICO.

### PLANT OF F. C. BARKER.

This plant is located on the ranch of Mr. F. C. Barker, about 1 mile south of Las Cruces, N. Mex. The pumping plant is used to irrigate about 20 acres of garden truck. Water is obtained from a 6-inch well, 48 feet deep, containing 12 feet of slotted galvanized-iron strainer at the bottom. The water is raised by a No. 3 Byron Jackson horizontal-shaft centrifugal pump, driven by a 5-horsepower Otto gasoline engine. The engine is belted directly to the pump from a 20-inch driving pulley to a 6-inch driven pulley. The engine made 334 revolutions and from 92 to 97 explosions per minute. The speed of the pump was 1,110 revolutions per minute.

The vacuum-gage tap was 2.92 feet above the water plane in September, 1904, and 17.73 feet below the center of 3-inch horizontal discharge pipe. The lift of the pump above the vacuum-gage tap when discharging into the first of two irrigation reservoirs is 17.73 feet.

The lift above the vacuum-gage tap when discharging into the second irrigation reservoir was 20.18 feet. The vacuum gage read 24.50, which, when corrected for altitude, is equivalent to 22.50 inches of mercury, or 25.4 feet of water. This makes the total lift when filling the second reservoir 45.58 feet.

The discharge of the pump was ascertained by determining, by means of a stop watch, the time required to fill a tank holding 47.6 gallons. As the tank was filled in 21.8 seconds, the discharge of the pump is 0.291 second-foot, or 131 gallons per minute. As the water level in the well is lowered 22.48 feet during pumping, the specific capacity of the well must be 5.83 gallon per minute, or 0.337 gallons per minute for each square foot of strainer.

This pumping plant is unusually well constructed. The machinery is well housed, and there are two concrete-lined reservoirs for storing

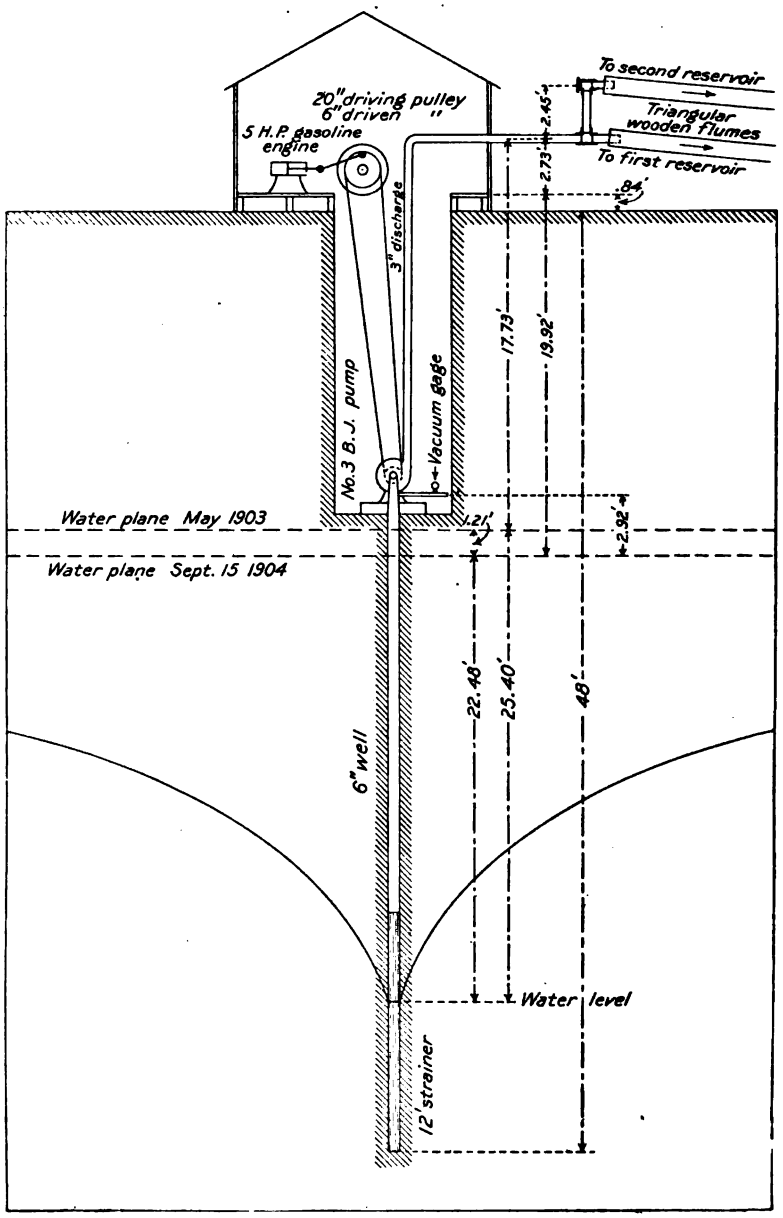



FIG. 18.—Diagram of pumping plant of F. C. Barker, near Las Cruces, N. Mex.

water for irrigation. It takes the pump eight hours to fill a reservoir, which is emptied in about an hour's irrigation. The cost of the plant complete was $1,200.

The amount of gasoline used was not accurately determined, but it hardly exceeded one-half gallon per hour when the engine was developing about its full horsepower. With gasoline at 17 cents a gallon, the fuel cost may safely be put at 9 cents an hour. On this basis the fuel cost of water was $0.0115 per 1,000 gallons, $3.73 per acre-foot, and $0.000252, or one-fortieth of a cent per 1,000 foot-gallons.

### PLANT OF J. C. CARRERA.

This plant is located on the ranch of J. C. Carrera, about half way between Las Cruces and Mesilla Park, N. Mex., near the east or upper highway between the Agricultural College and Las Cruces. The well is 6 inches in diameter and 58 feet deep, and is equipped with a slotted galvanized-iron strainer 5½ inches in diameter by 15 feet long. The water is recovered by a No. 5 Byron Jackson horizontal-shaft centrifugal pump, driven by an 8-horsepower Fairbanks-Morse gasoline engine. The engine ran at a speed of 234 revolutions a minute, missing no explosions. The pump was driven at a speed of 560 revolutions a minute by direct belting to engine from 20-inch driving pulley to 8-inch driven pulley.

The vacuum-gage tap was 12.65 feet below the center of the 5⅝-inch horizontal discharge pipe and 5.72 feet above the water, which, when the well was first dug, three years before the test, was 2.7 feet higher than at present. The vacuum gage read 14.5 inches, which gives, after correction for altitude, 12.5 inches of mercury or 14.2 feet of water. The total lift was therefore 26.85 feet. The discharge of the pump was 1.44 second-feet or 648 gallons a minute. The water in the well was lowered only 8.48 feet, so that the specific capacity of the well is 76.4 gallons per minute, or 3.53 gallons per minute for each square foot of well strainer.

Twelve gallons of gasoline were used for eleven hours' run, including the amount consumed by igniting torch. With gasoline at 17 cents per gallon, the fuel cost of water is 17¾ cents an hour, 0.456 cents per 1,000 gallons, $1.48 per acre-foot, and $0.017 or one fifty-ninth of a cent per 1,000 foot-gallons.

### PLANT OF FRANK BURKE NEAR MESILLA, N. MEX.

This plant is located on the ranch of Frank Burke, about one-half of a mile south of Mesilla Park, N. Mex. Water is obtained from a 12-inch well, 52 feet deep, containing 11½ feet of slotted galvanized-iron strainer at the bottom. The well passes through 8 feet of soil and sand, 14 feet of quicksand with small pebbles, and 38 feet of sand and gravel of maximum size 3 inches. The water is recovered by a No. 6 Byron Jackson horizontal-shaft centrifugal pump, driven by a 21-horsepower Otto gasoline engine. The engine is belted to a pump

shaft from 40-inch driving pulley on engine, thence to a 20-inch driven pulley on countershaft, thence from 16-inch driving pulley on countershaft to 10-inch driven pulley on pump shaft. The speed of pump

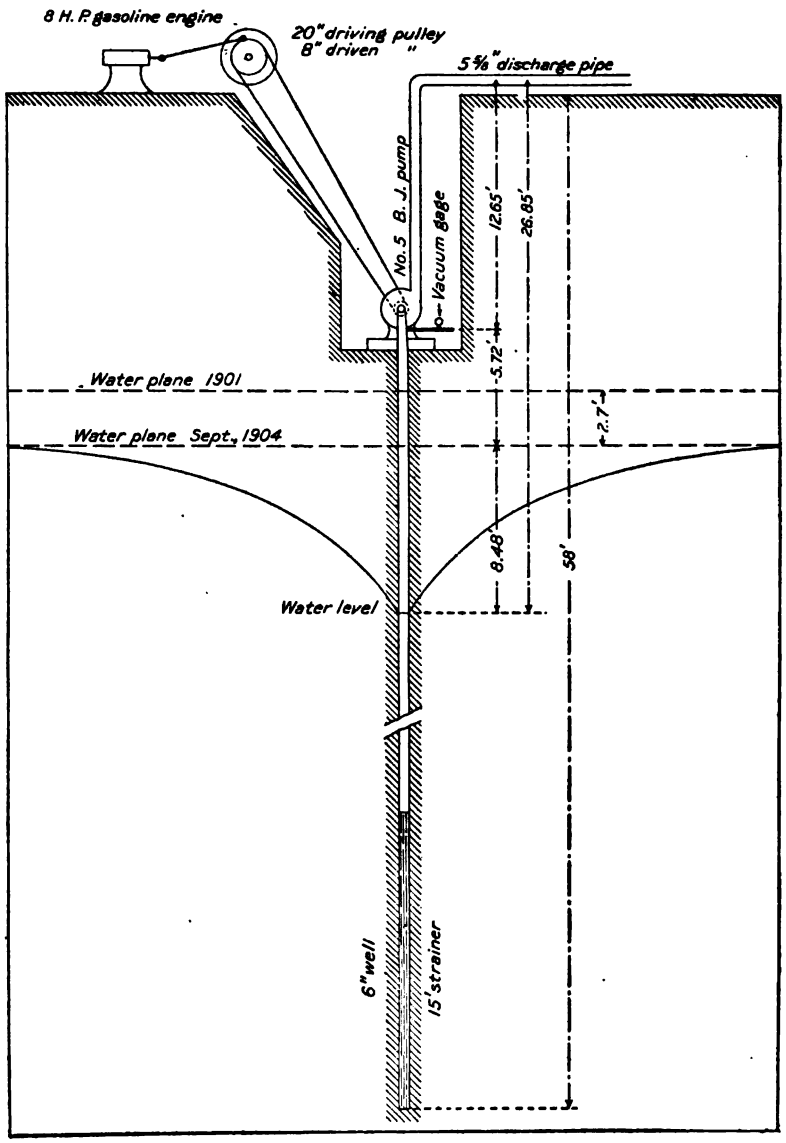



FIG. 19.—Diagram of pumping plant of J. C. Carrera, near Las Cruces, N. Mex.

during the test was 733 revolutions per minute, and of the engine 240 revolutions per minute.

The vacuum gage was placed in the goose neck of the pump, and the tap was 14.85 feet below the center of the horizontal discharge

pipe. The vacuum gage read 25.25 inches, which, when corrected for altitude, is equivalent to 23.25 inches of mercury, or 25.6 feet of water. The total lift of the pump was, therefore, 40.45 feet.

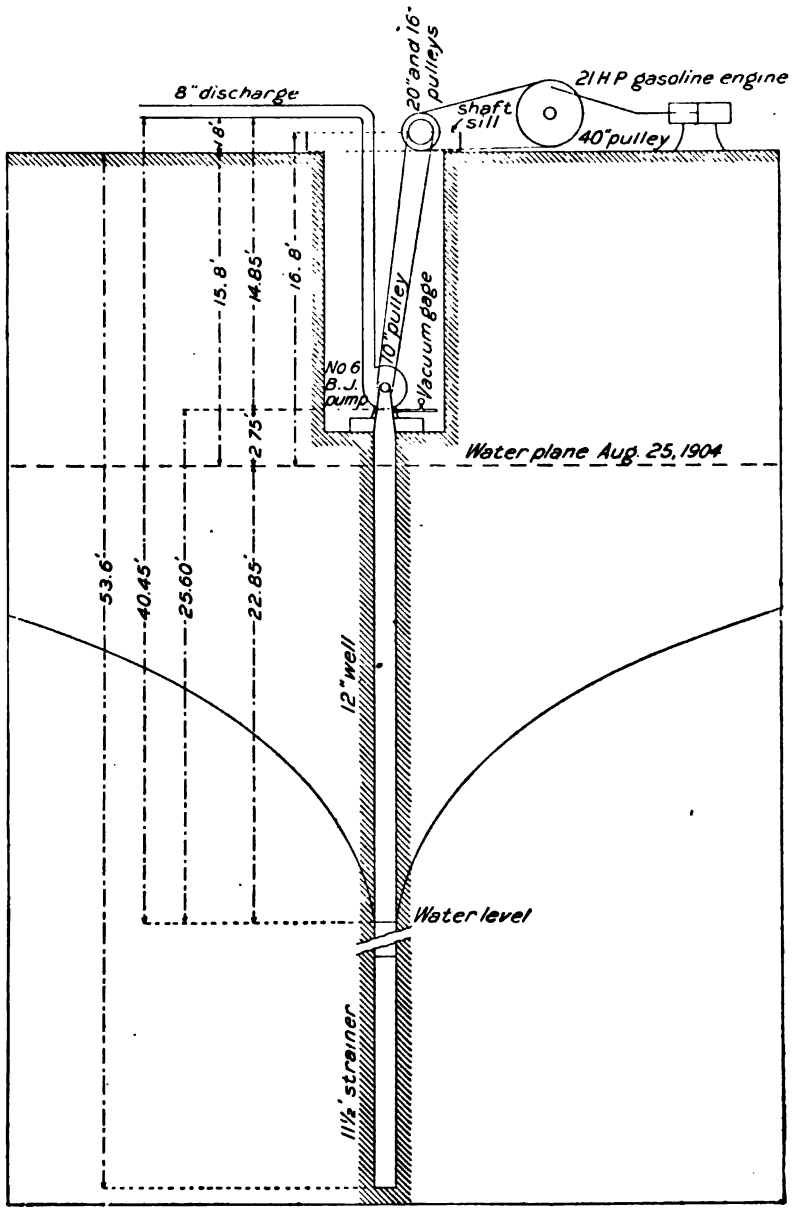



FIG. 20.—Diagram of pumping plant of Frank Burke, near Mesilla Park, N. Mex.

The discharge of the pump was determined by integrating with a Price acoustic-current meter in a rectangular flume through which the

water was led after it had passed into the main ditch. The area of the water at the selected cross section was 0.383 square foot, and the mean velocity was 4.21 feet per second, making the discharge 1.61 second feet, or 725 gallons per minute. The level of the water in the well was lowered 22.85 feet by pumping, whence it is concluded that the specific capacity of the well is 25.4 gallons per minute, or 0.934 gallon per minute for each square foot of strainer.

This plant had been run for very short periods and no conclusive estimate of the amount of gasoline consumed can be made. During the test the engine was not run at its full capacity. The gasoline tank was so constructed that an accurate measurement could not be made. The amount of gasoline consumed, however, did not vary greatly from 2 gallons an hour. With gasoline at 17 cents per gallon, the fuel cost of water was 34 cents per hour, $0.0078 per 1,000 gallons, $2.52 per acre-foot, and $0.000193, or one fifty-second of a cent per 1,000 foot-gallons.

### PLANT OF MRS. E. M. BOYER.

The plant of Mrs. E. M. Boyer is located about one-fourth of a mile north of the railroad station at Las Cruces, N. Mex. Water is obtained from a well 52 feet deep cased with 6-inch standard pipe. The well is equipped with a slotted galvanized iron Porcher strainer 5½ inches diameter and 12 feet in length. The slots are three-sixteenths by 1½ inches. The well driller reports the following log of the well: 18 inches of soil; dry sand to 20 feet; quicksand below this, changing to coarse gravel and bowlders containing sand, in which the strainer was left. The pumps threw a good heavy stream of water as soon as started, only a few bushels of sand being drawn through the strainer.

Water is recovered by means of a No. 5 Byron Jackson horizontal-shaft centrifugal pump, driven by a 12-horsepower Olds gasoline engine. The engine is directly belted to a pump from 30-inch driving pulley to 8-inch driven pulley. The engine made 208 revolutions and 93 explosions per minute. The speed of the pump was 728 revolutions per minute. The vacuum gage during pumping stood at 22 inches, which, corrected for altitude, is equivalent to 20 inches of mercury, or 22.7 feet of water. On September 19, 1904, the water plane stood 2.94 feet below the vacuum-gage tap, or 3,836.867 feet above mean sea level. The vacuum-gage tap was 14.3 feet below the surface and 17.6 feet below the center of the 6-inch horizontal discharge pipe. The discharge of the pump was 1.46 second-feet, or 658 gallons per minute. The total lift of the pump was 40.3 feet, and the water level in the well was lowered 19.76 feet during pumping. The specific capacity of the well is thus 33.3 gallons per minute, or 1.969 gallons per minute for each square foot of strainer.

A fifty-hour test of this pumping plant was run by F. H. Bascom, of

Las Cruces, who reports that 48 gallons of gasoline were consumed during that time. With gasoline at 17 cents a gallon the fuel cost of

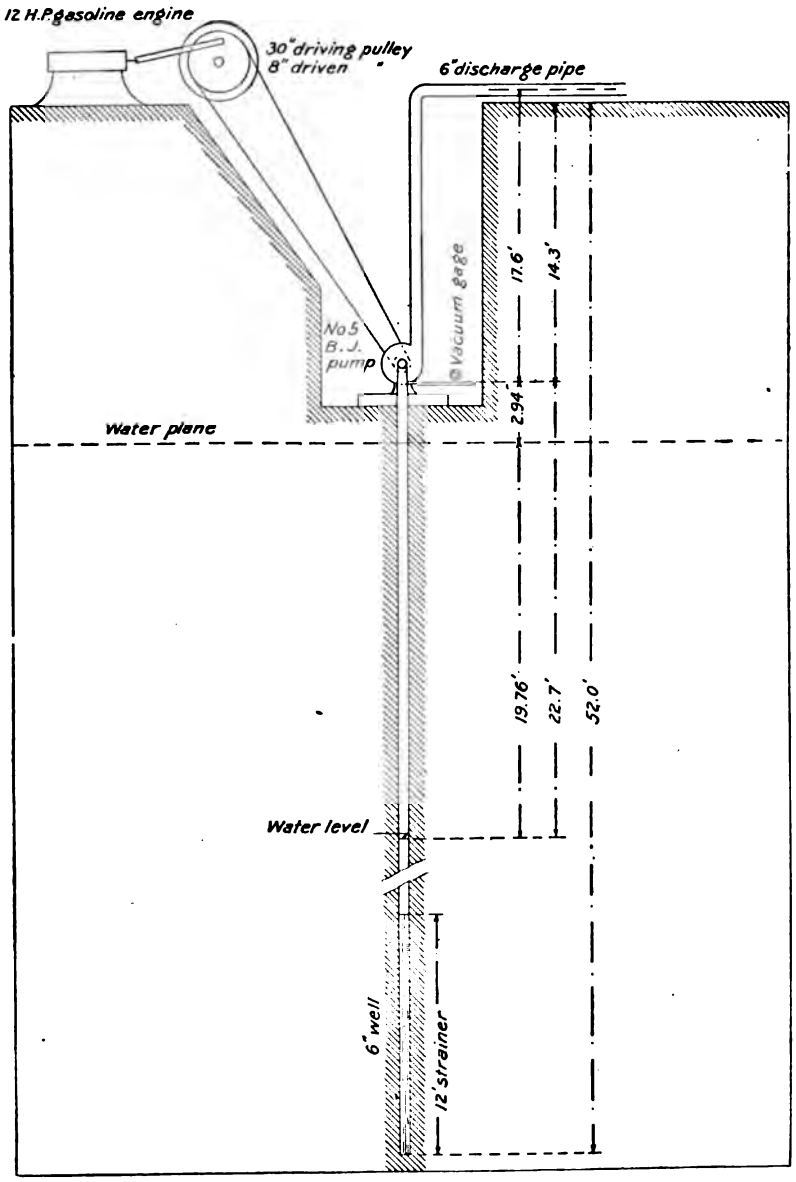



FIG. 21.—Diagram of pumping plant of Mrs. E. M. Boyer, near Las Cruces, N. Mex.

water would be 16.3 cents an hour, 0.412 cents per 1,000 gallons, $1.34 per acre-foot, and $0.000102, or one ninety-eighth of a cent per 1,000 foot-gallons.

PLANT OF W. N. HAGER.

This pumping plant is located on the ranch of W. N. Hager, about one-half mile west of the railroad station at Mesilla Park, N. Mex.

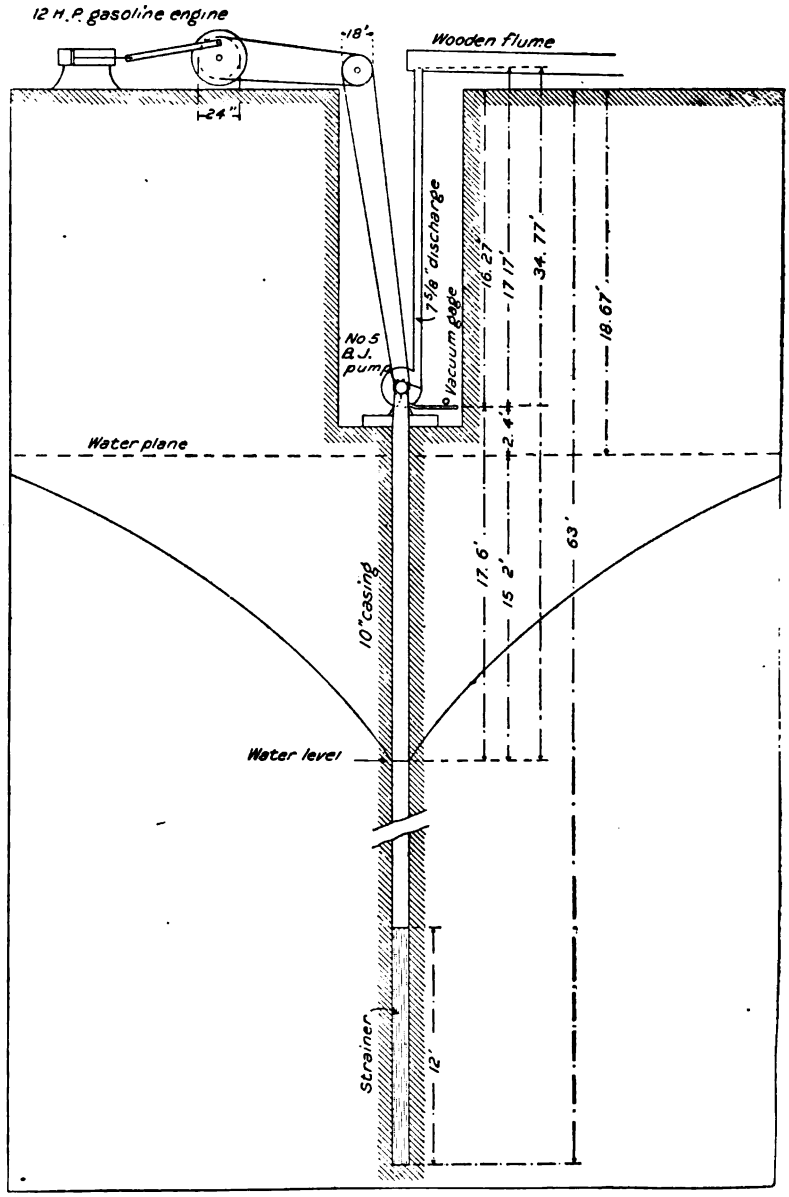



FIG. 22.- Diagram of pumping plant of W. N. Hager, near Mesilla Park, N. Mex.

Water is obtained from a 10-inch well, 63 feet deep, containing a 12-foot, slotted galvanized-iron Porcher strainer, 9¾ inches in diam-

eter. The pumping is done by a No. 5 Byron Jackson horizontal-shaft, centrifugal pump, directly connected to the 10-inch well casing. The pump is driven by a 12-horsepower Weber gasoline engine, power being transmitted by a belt from 24-inch driving pulley to 18-inch pulleys on countershaft, thence to 8-inch driven pulley on pump shaft.

At the time of the test the engine made 243 revolutions and 76 explosions per minute. The speed of the pump was 668 revolutions a minute. The pump discharges through a 7⅝-inch vertical discharge pipe into a rectangular wooden flume. The discharge was measured by integrating in this flume with a Price acoustic current meter. The width of flume was 1.63 feet. At the selected cross section the water had an average depth of 0.308 feet and an average velocity of 1.171 feet per second. The total discharge was therefore 0.590 second-feet, or 325 gallons a minute. An attempt was made to catch the water in a tub holding 15.9 gallons. The time required to fill the tub was determined by a stop watch, but as the water had to be diverted into the tub by closing a gate at the end of the rectangular flume, the results are not satisfactory. The average time required to fill the tub in seven trials was 4.3 seconds, indicating a discharge of only 209 gallons a minute. This result is known to be valueless, but it illustrates the impracticability of measuring such a discharge by means of a small tub, unless the tub can be placed directly under the discharging stream of water without the necessity of diverting the water to one side.

The vacuum-gage tap was 16.27 feet below the surface, and 16.84 feet below the top of the 7⅝-inch discharge pipe. The water jet is 0.33 feet above the mouth of the discharge pipe. The vacuum gage read 17.5 inches, or 15.5 inches of mercury, when corrected for altitude. This is equivalent to 17.6 feet of water, making total lift of pump 34.77 feet. The vacuum-gage tap was 2.405 feet above the water plane, so that the water in well was lowered 15.2 feet during pumping. The specific capacity of the well is therefore 22.5 gallons per minute, or 0.76 gallons per minute for each square foot of well strainer.

The amount of gasoline used was determined by measurement in a round tank 1.87 feet in diameter. In one hour a depth of 0.09 feet of gasoline was consumed, or 1.84 gallons. With gasoline at 17 cents per gallon, the fuel cost of water was 31 cents per hour, 1.6 cents per 1,000 gallons, and $5.14 per acre-foot. The lift being 34.77 feet, the cost of fuel for 1,000 foot-gallons was $0.00046, or one twenty-second of a cent.

### PLANT OF A. L. HINES.

This plant is located on the ranch of Dr. A. L. Hines, about 1 mile north of east from the old village of Mesilla. Water is obtained from a well 5⅝ inches in diameter and 59 feet deep. The log of this well showed 8 feet of soil, 11 feet of dry sand, 28 feet of quicksand, and 12

feet of gravel on top of quicksand of unknown thickness. The water is recovered by a No. 4 Rumsey horizontal-shaft centrifugal pump, which is driven by an 8-horsepower vertical gasoline engine placed on

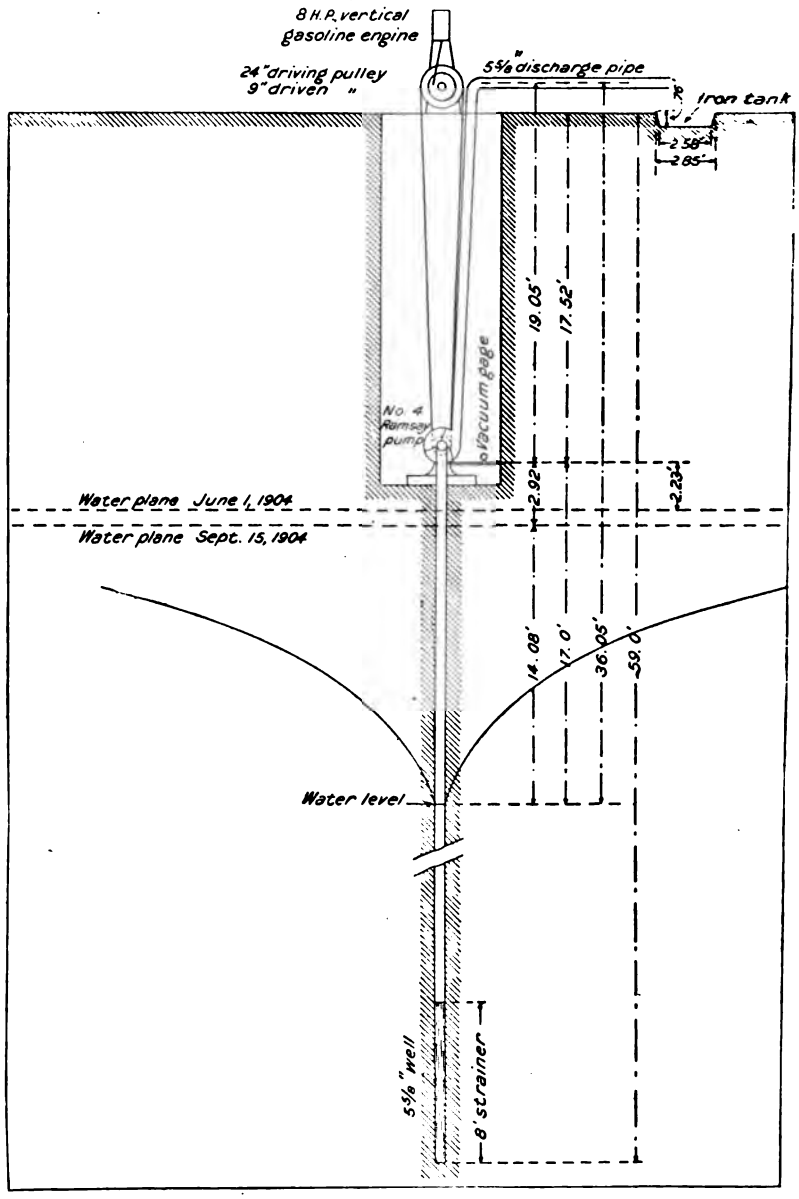



FIG. 23.—Diagram of pumping plant of A. L. Hines, near Mesilla, N. Mex.

sills extending across the top of the well pit. The engine was manufactured by the Chicago Gas Engine Company. It is directly belted to pump shaft from a 24-inch driving pulley and 9-inch driven pulley.

The engine made 238 revolutions and 119 explosions per minute. The speed of the pump was 594 revolutions per minute.

The water plane was 2.92 feet below the vacuum-gage tap in gooseneck of pump on September 15, 1904, and 2.23 feet below on June 1, 1904; the water plane had fallen, therefore, in this interval about 8½ inches. The pumping plant had been in use only twenty days during the summer. The vacuum-gage tap was 19.05 feet below the center of the horizontal 5⅝-inch discharge pipe. The vacuum gage read 17 inches, which, corrected for altitude, is equivalent to 15 inches of mercury, or 17 feet of water. The total lift of the pump was, therefore, 36.05 feet.

The discharge was measured with great precision by determining with a stop watch the time required to fill a wrought-iron rectangular tank. The water was conducted across the tank by means of an extra piece of iron pipe until the pumping plant had been in operation for some time, when the extra pipe was suddenly pulled off. The tank held 15.08 cubic feet and was filled in 30.6 seconds. The discharge was, therefore, 0.492 second-foot, or 271 gallons per minute.

An excellent opportunity was offered for testing the accuracy of estimating the discharge from partly filled pipes by determining the mean velocity of the stream by a small current meter. Only 44.3 per cent of the cross section of the 5⅝-inch discharge pipe was filled by the water raised by the pump. The area of the cross section was 0.076 square foot, and the velocity of the water, as given by the current meter, was 8.47 feet per second. The discharge was, therefore, 0.642 second-foot, or 290 gallons per minute. The true discharge was 271 gallons per minute, showing an error of 5.3 per cent in the meter determination.

The water in the well was lowered 14.08 feet during pumping; therefore, the specific capacity of the well was 19.2 gallons per minute. As the area of the well strainer was 11.3 square feet, the specific capacity per square foot of well strainer was 1.79 gallons per minute.

At this plant 1.5 gallons of gasoline were used per hour. This is at least 50 per cent more than should have been used. With gasoline at 17 cents a gallon, the hourly cost of fuel was 25½ cents. As the yield was 16,250 gallons of water an hour, the fuel cost was $0.0157 per 1,000 gallons, $5.10 per acre-foot, and $0.000435, or one twenty-third of a cent per 1,000 foot-gallons.

### PLANT OF THEODORE ROUALT.

This plant is on the ranch of Theodore Roualt, about 3 miles northwest of Las Cruces, N. Mex. Water is obtained from a 10-inch well 48 feet deep that contains 10 feet of 9¾-inch slotted galvanized-iron strainer. It is raised by a No. 3 Van Wie vertical-shaft centrifugal pump, driven by a 10-horsepower Nagle steam engine, on 18-horsepower

horizontal wood-burning boiler. The engine is directly belted to the pump shaft from a 30-inch driving pulley to a 12-inch driven pulley.

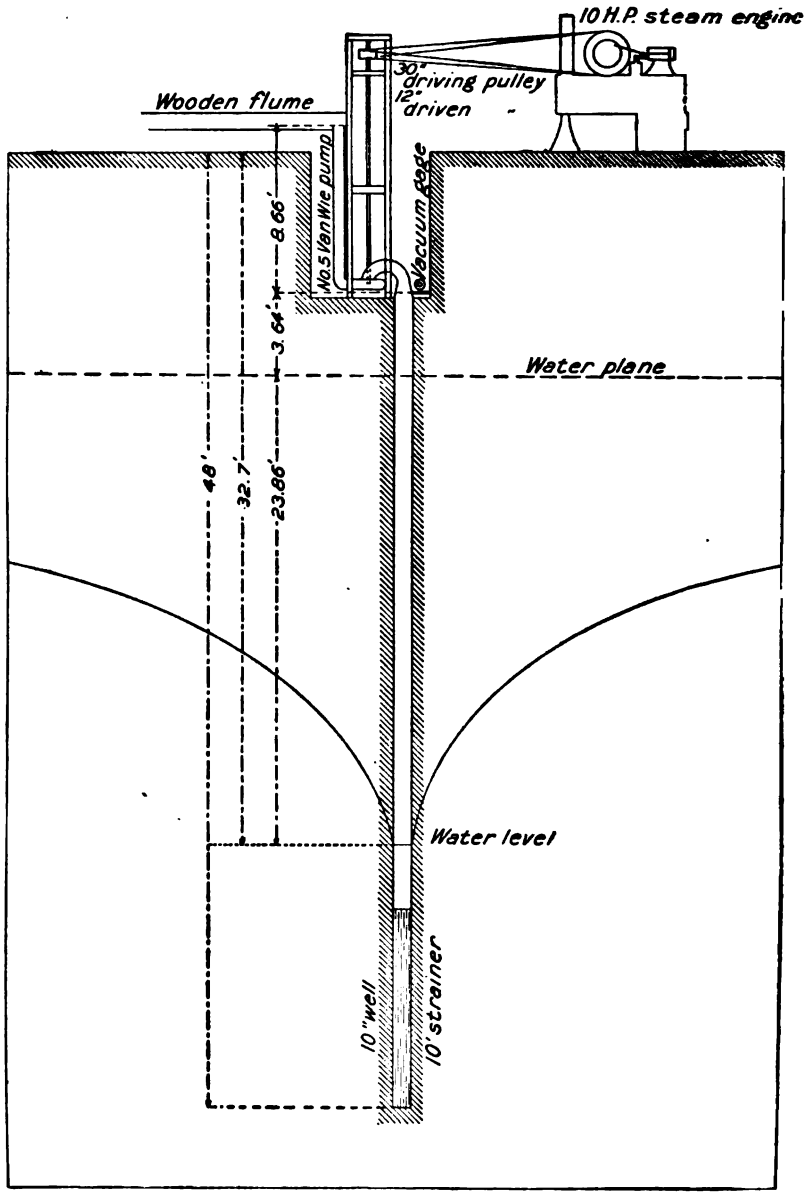



FIG. 24.—Diagram of pumping plant of Theodore Roualt, near Las Cruces, N. Mex.

The water is discharged through an 8-inch vertical pipe into a rectangular flume.

The engine made 205 and the pump 525 revolutions per minute.

*A*. DISCHARGE FROM WELL NO. 1, HORACO RANCH COMPANY.

*B*. PUMPING PLANT OF T. ROUALT.

The steam pressure varied between 81 and 83 pounds. The vacuum-gage tap was 3.64 feet above the water plane, 7.96 feet below the top of bottom plank of flume, and 8.66 feet below the top of water jet.

The vacuum gage read 24.25 inches, which is equivalent, when corrected for altitude, to 22.25 inches of mercury, or 25.5 feet of water, making the total lift 34.16 feet. The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The selected cross section had a width of 1.19 feet, an average depth of 0.35 foot, and an area of 0.417 square foot. As the average velocity was 1.867 feet per second, the discharge was 0.78 second-foot or 351 gallons per minute. From this it is estimated that the specific capacity of the well is 16 gallons per minute, or 0.627 gallon per minute for each square foot of strainer.

The cost of fuel used for pumping can be readily estimated from careful tests by Mr. Roualt. For one irrigation of a 70-acre field of tomatoes the pump was run twenty-eight days of twenty-four hours, and 75 cords of cottonwood, costing $2 per cord, were consumed. During the twenty-eight days of twenty-four working hours each 14,150,000 gallons, or 43.5 acre-feet, of water were pumped. The total cost of wood being $120, the fuel cost of water was 1.06 cents per 1,000 gallons, $3.45 per acre-foot, and $0.00031, or about one thirty-second of a cent, per 1,000 foot-gallons.

### PLANT OF G. H. TOTTEN.

This plant is located on the ranch of G. H. Totten, about one-half of a mile west of the old village of Mesilla, N. Mex. Water is obtained from a 10-inch well, 62 feet deep, that contains 11½ feet of 9-inch slotted galvanized-iron strainer. It is raised by a No. 6 Byron Jackson horizontal-shaft centrifugal pump, driven by a 28-horsepower Ohio gasoline engine. The engine is belted from a 36-inch driving pulley to a 16-inch pulley on countershaft; thence from a 15-inch pulley on countershaft to a 10-inch pulley on pump. The engine made 205 revolutions and an average of 78 explosions per minute. The speed of the pump was 692 revolutions a minute.

The water is delivered through an 8-inch vertical discharge pipe into a horizontal rectangular wooden flume. The vacuum-gage tap on pump was 3.9 feet above the water plane, 16.83 feet below top of discharge pipe, and 16.95 feet below top of water jet. The vacuum gage read 25.25 inches, which is equivalent, after correction for altitude, to 23.25 inches of murcury, or 26.4 feet of water. The total lift is, therefore, 43.35 feet.

The discharge was measured by integrating with a Price acoustic current meter in rectangular flume. The selected cross section had a width of 1.83 feet, an average depth of 0.38 foot, and an effective area

of 0.695 square foot. The mean velocity of the water was 1.482 feet per second, giving a total discharge of 1.03 second-feet, or 464 gallons per minute.

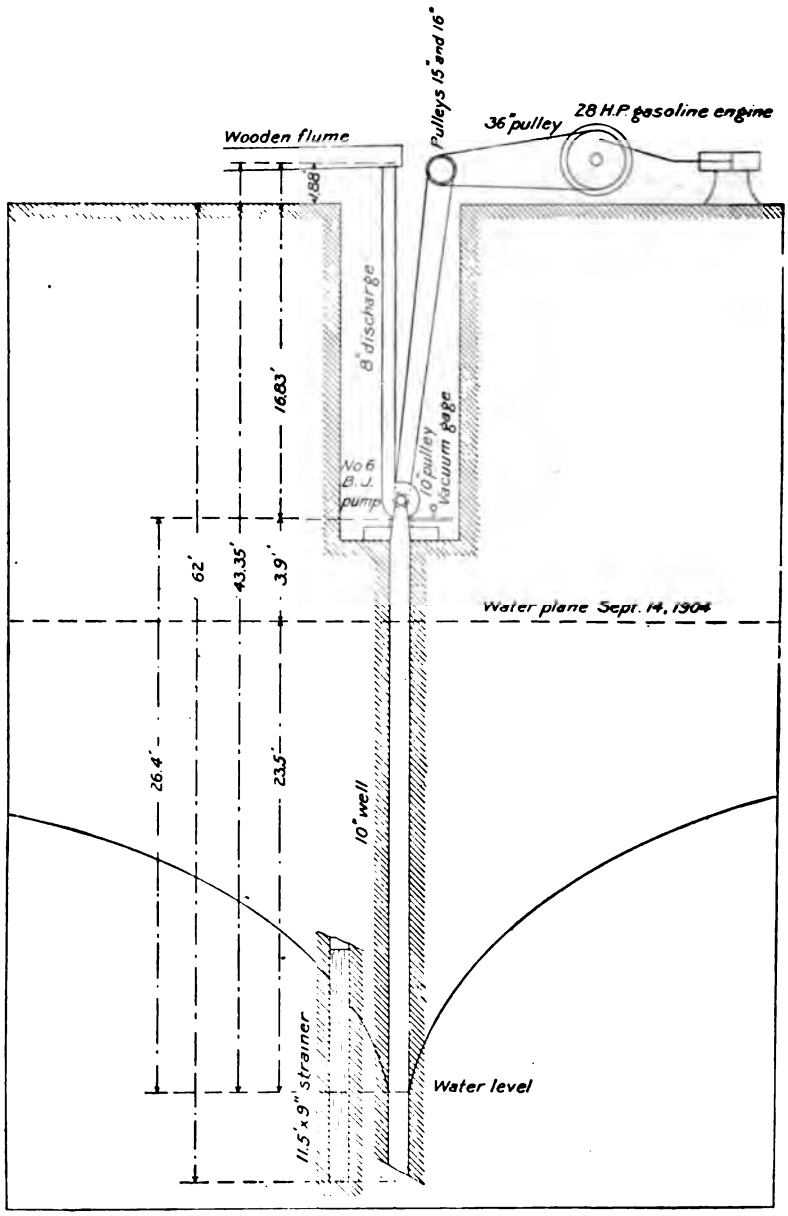



FIG. 25.—Diagram of pumping plant of G. H. Totten, near Mesilla, N. Mex.

The water in the well was lowered 22.5 feet during pumping, from which the specific capacity of the well is estimated to be 20.6 gallons a minute, or 0.76 gallon per minute for each square foot of strainer.

The discharge was also determined from the dimensions of the parabola of flow as the water left the flume. The end of the flume was almost exactly level and the water fell freely for a sufficient distance to permit the determination of the dimensions of the parabola of the fall. This is shown in fig. 26. The water had an average depth of 0.171 foot at the end of flume, and in a total fall of 2.05 feet moved forward 1.285 feet. According to the laws of falling bodies, a body falls 2.05 feet in 0.356 second. If the water advances 1.285 feet in 0.356 second, its mean velocity per second would be 1.285 divided by 0.356, or 3.6 feet. The area of the stream is 0.171 by 1.83, or 0.313 square foot. This gives a total discharge of 1.13 second-feet, or 507 gallons per minute. These results are undoubtedly slightly too large.

The pumping plant had been used but a short time, and no experimental run had been made to determine the quantity of gasoline required. As the gasoline tank was situated so that without a consid-

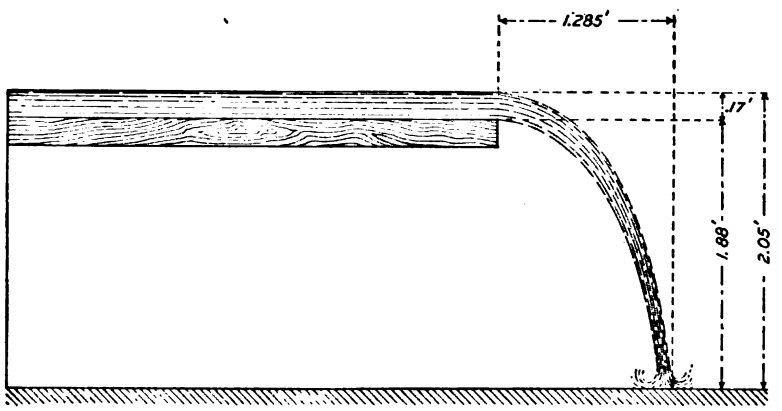



FIG. 26.—Parabola of discharge from flume at Totten's well.

erable expenditure of time it was impracticable to ascertain the amount of gasoline used, no determination was made during the test. However, it was estimated that the 28-horsepower engine gave 22 effective horsepower. It may therefore be safely assumed that about 2.2 gallons of gasoline were used per hour. If this amount were used, and gasoline costs 17 cents per gallon, the fuel cost of water would be 37 cents an hour, $0.0133 per 1,000 gallons, $4.34 per acre-foot, and $0.000307, or about one thirty-third of a cent per 1,000 foot-gallons.

## PLANT AT AGRICULTURAL COLLEGE.

This plant consists of a 12-inch and a 6-inch well located on the experimental farm of the New Mexico Agricultural College. A complete test of this plant was not made, as the work with these wells is frequently reported upon by members of the faculty of the Agricul-

tural College. Only sufficient tests were made to determine the specific capacity of the large well in order to make comparisons possible with the other pumping plants in the valley. At the time of the test a

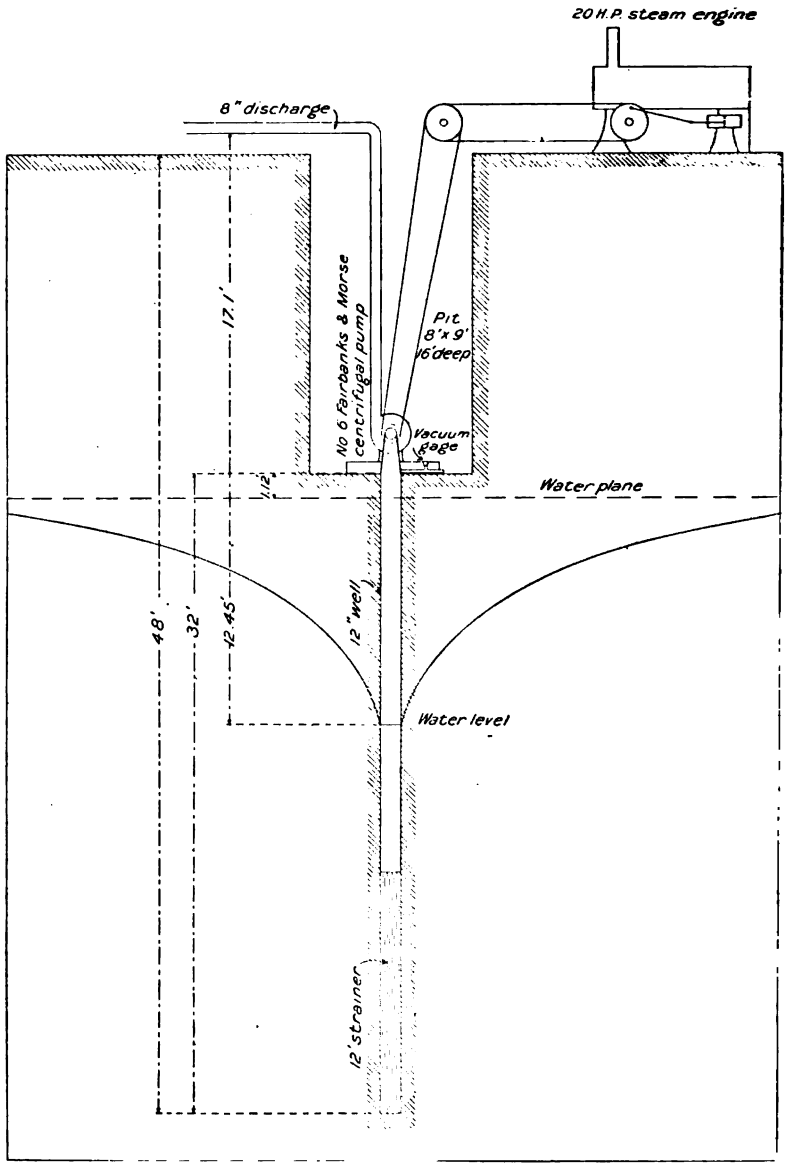



FIG. 27.—Diagram of Agricultural College 12-inch well, Mesilla Park, N. Mex.

No. 6 Fairbanks-Morse centrifugal pump was in use, but the pumps are frequently changed for experimental purposes. The pump is speeded so as to discharge 1,000 gallons a minute at the measuring

weir, in order that a known amount of water may be provided for the experimental plats of ground.

At the time of the test there was in use a 30-horsepower steam engine, which has ample power to drive pumps placed on both wells. When both wells are used, about 1,800 gallons per minute can be obtained.

On August 25, 1904, the vacuum gage read 13 inches, which, corrected for altitude, is equivalent to 11 inches of mercury, or 12.45 feet of water. The lift above the vacuum-gage tap was 17.10 feet, making the total lift 29.55 feet. The water level in the well was lowered 11.37 feet by pumping, from which the specific capacity of the well is computed to be 88 gallons per minute. As the well strainer is 12 inches in diameter, 12 feet long, and 27.6 square feet in area, the specific capacity per square foot of strainer is 2.32 gallons per minute.

The cost of fuel per acre-foot, as given in the table on p. 35, is taken from the bulletin issued by Professors Vernon and Lester in 1903. These results were obtained with a 20-horsepower steam engine formerly used. These results are included in the table for the purpose of comparison with the results at other plants.

## TESTS OF PUMPING PLANTS NEAR BERINO, N. MEX.

### PLANTS OF HORACO RANCH COMPANY.

The Horaco Ranch Company has three plants in an east-west line on a ranch just west of Berino, N. Mex. The east well is No. 3, the middle well is No. 1, and the west well is No. 2.

Well No. 3 is 62 feet deep. It is cased with 9⅝-inch pipe and contains 18 feet of strainer made of 9⅝-inch casing drilled with forty 1½-

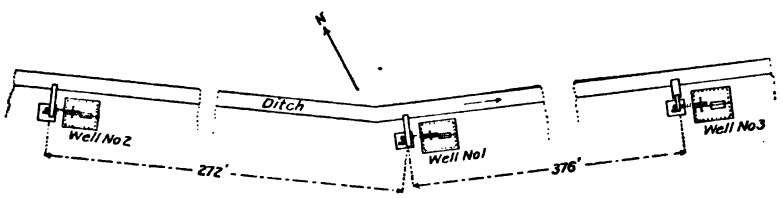



FIG. 28.—Plan of pumping plants of the Horaco Ranch Company, Berino, N. Mex.

inch holes to every linear foot of strainer and wound with No. 9 galvanized-iron wire wrapped so as to leave horizontal slots one-eighth of an inch in width. This strainer is locally known as the "Mott" strainer.

Water is obtained by means of a No. 5 Byron Jackson horizontal-shaft centrifugal pump, driven by a 12-horsepower Weber gasoline engine. The water is discharged through a 7-inch pipe, which rises

at an angle of 45° from the pump in the well pit. The engine made 244 revolutions and 97 explosions per minute. The pump made 692 revolutions a minute, and was belted directly to the engine from a

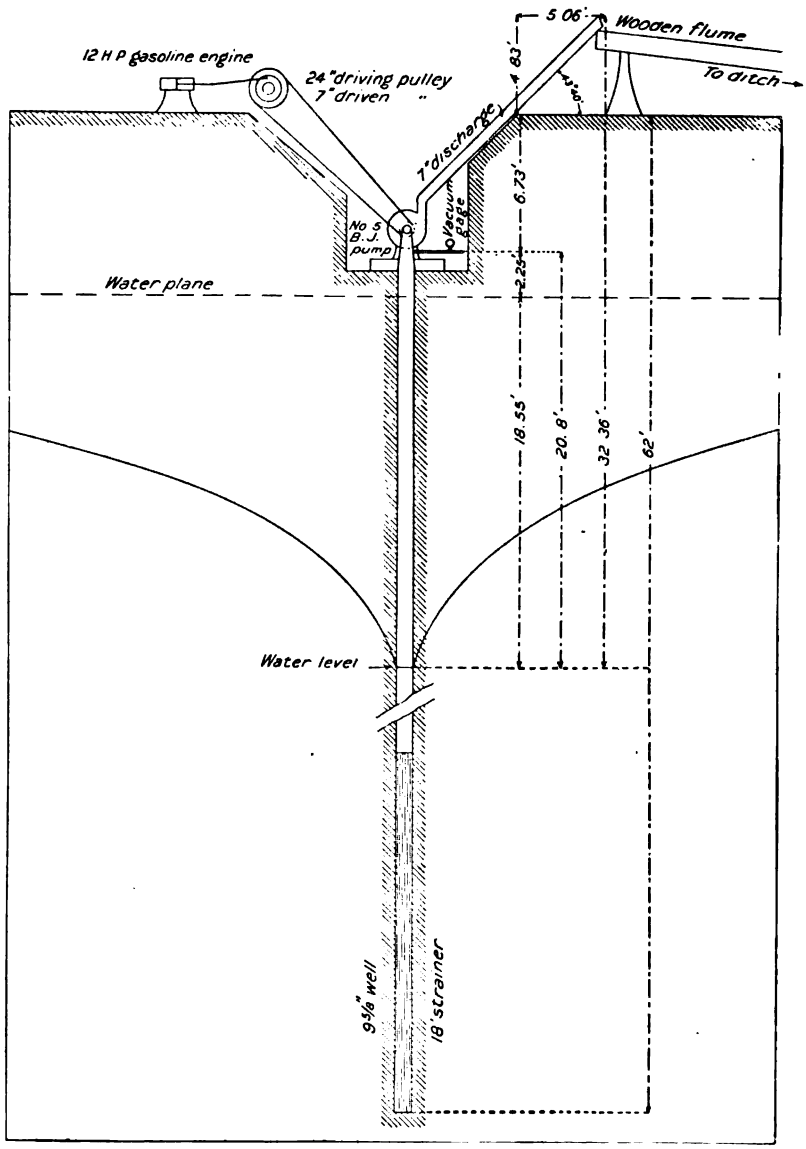



FIG. 29.—Diagram of pumping plant No. 3, Horace Ranch Company.

24-inch driving pulley to a 7-inch driven pulley. On September 11, 1904, the water plane was 2.25 feet below the vacuum-gage tap, which was 11.56 feet below the end of the discharge pipe. The

vacuum gage read, after one hour's pumping, 19.8, which, when corrected for altitude, is equivalent to 17.8 inches of mercury, or 20.8 feet of water. The total lift of the pump was, therefore, 32.36 feet.

The discharge was measured by holding a small Price acoustic current meter in the mouth of the 7-inch discharge pipe. It was 1.71 second-feet, or 750 gallons a minute.

As determined by Mr. E. L. Houck, principal owner of the Horaco ranch, a barrel of 50 gallons of gasoline was consumed by the engine at well No. 3 in fifty-three hours. With gasoline at 17 cents per gallon the fuel cost of water was 16 cents an hour, or $0.00356 per 1,000 gallons, or $1.16 per acre-foot. Since the total lift of the pump is 31.76 feet, the cost of fuel for 1,000 foot-gallons is $0.000112, or one eighty-ninth of a cent. The consumption of gasoline at the time of the test was measured by noting the changing level of the gasoline in a cylindrical tank 1.85 feet in diameter. The change of level in one hour was 0.0867 foot. This is equivalent to 1.76 gallons an hour. On this basis the fuel cost of water was $2.23 per acre-foot, and $0.000314, or one forty-seventh of a cent per 1,000 foot-gallons.

Well No. 1 of the Horaco Ranch Company is 376 feet west from well No. 3. It is 75 feet deep, is cased with 7⅝-inch pipe, and equipped with 18 feet of Mott strainer. Water is delivered through a 7⅝-inch vertical pipe opening into a horizontal wooden flume. It is raised by a No. 5 Byron Jackson horizontal-shaft centrifugal pump, driven by a 12-horsepower Weber gasoline engine. The engine made 238 revolutions and 106 explosions a minute. The pump made 815 revolutions a minute and was belted directly to the engine from a 24-inch driving pulley to a 7-inch driven pulley.

The vacuum-gage tap was 0.43 foot above the water plane on September 11, 1904. It was 7.1 feet below the surface and 8.95 feet below the end of vertical discharge pipe. As the water jet rose 0.762 foot above the end of the discharge, the total lift above the vacuum-gage tap was 9.71 feet. The vacuum gage read 14.5, which, corrected for altitude, is equivalent to 12.5 inches of mercury, or 14.18 feet of water. The total lift of the pump was, therefore, 23.89 feet.

The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The selected cross section had an average depth of 0.278 foot, an average width of 1.42 feet, and an area of 0.395 square foot. The average velocity of the water was 4.707 feet per second, giving a discharge of 1.86 second-feet, or 837 gallons per minute.

The area of the well strainer is 36 square feet. The water level in the well was lowered 13.75 feet during pumping, and therefore the specific capacity of the well is 60.8 gallons per minute, or 1.69 gallons per minute for each square foot of strainer.

Although the amount of water obtained at well No. 1 is very much greater than at well No. 3, the cost for fuel is substantially the same. The consumption of gasoline is slightly less than 1.2 gallons an hour. With gasoline at 17 cents a gallon, the hourly cost is 20 cents. The

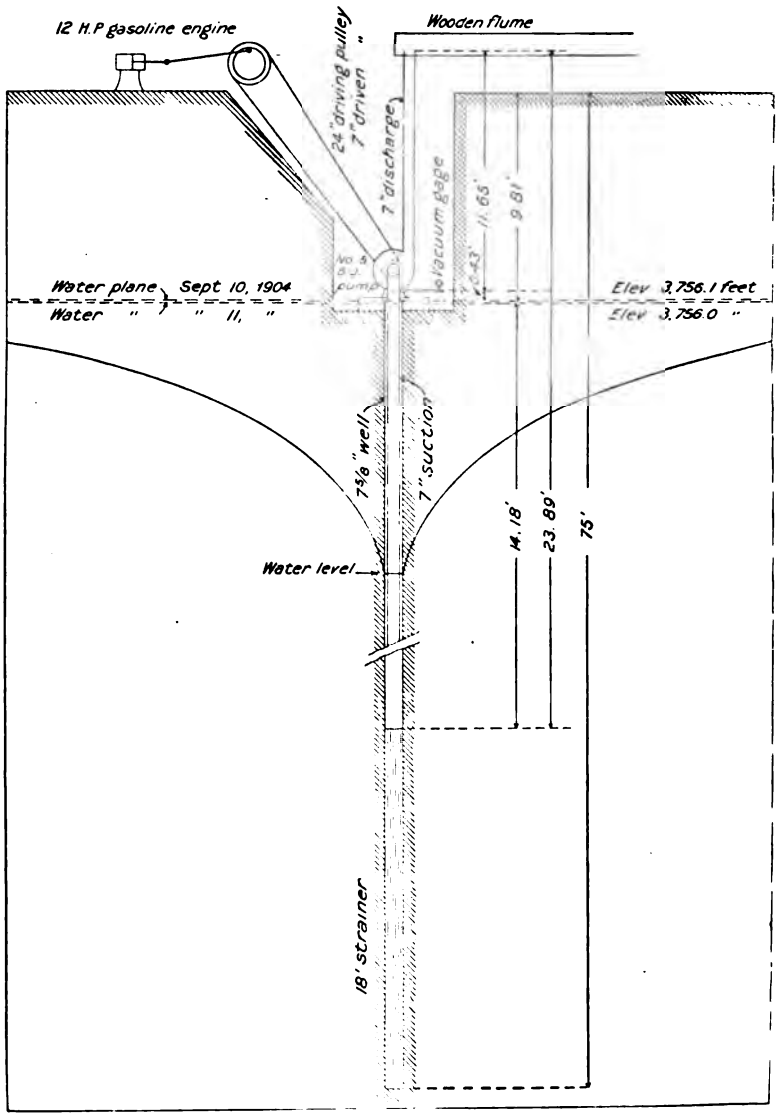



FIG. 30.—Diagram of pumping plant No. 1, Horace Ranch Company.

amount of water obtained being 837 gallons a minute, or 50,220 gallons an hour, the fuel cost was $0.004 per 1,000 gallons, or $1.30 per acre-foot. The lift at well No. 1 being 23.89 feet, the cost of fuel for each 1,000 foot-gallons was $0.000167, or one-sixtieth of a cent.

Well No. 2 of the Horaco Ranch Company is 376 feet west of well No. 1. It is 53 feet deep, is cased with 9⅝-inch pipe, and is equipped with 18 feet of Mott strainer at the bottom. Water is raised by a No. 5 Byron Jackson horizontal-shaft centrifugal pump, driven by a

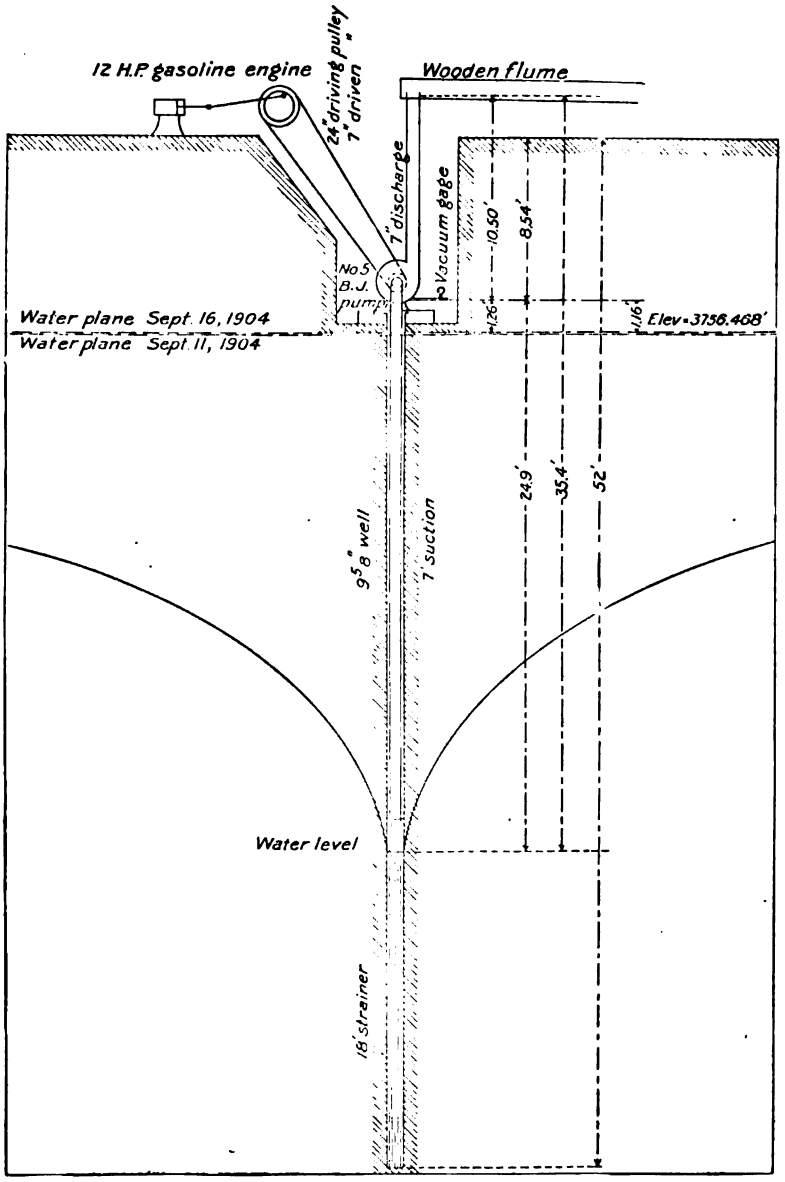



FIG. 31.—Diagram of pumping plant No. 2, Horaco Ranch Company.

12-horsepower Weber gasoline engine. It is taken from the well through a 7-inch suction and discharged through a 7-inch vertical pipe into a horizontal flume. The engine made 239 revolutions and

103 explosions a minute. It was belted directly to the pump shaft from a 24-inch driving pulley to a 7-inch driven pulley. The speed of the pump was 700 revolutions a minute.

The vacuum-gage tap placed in the goose neck of the pump was 1.26 feet above the water plane and 10.02 feet below the top of the vertical discharge pipe. As the water jet rose 0.34 foot above the discharge pipe, the total lift of the pump above the vacuum-gage tap was 10.36 feet. The vacuum gage read 24 inches, which, corrected for altitude, is equivalent to 22 inches of mercury, or 24.9 feet of water. The total lift of the pump was therefore 35.26 feet.

The discharge was measured by integrating with a Price acoustic current meter in the rectangular flume. The selected cross section had an average depth of 0.251 foot, a width of 1.44 feet, and an area of 0.362 square foot. The mean velocity was 1.172 feet per second, which gives a total discharge of 0.425 second-foot, or 191 gallons per minute.

The water in the well was lowered 23.64 feet by pumping. This makes the specific capacity of the well 8.1 gallons per minute, or 0.178 gallon per minute for each square foot of strainer.

The consumption of gasoline by the engine at well No. 2 is known by comparison with that at well No. 3. Although the amount of water pumped is very much less than at well No. 3, the consumption of gasoline is as great, and even slightly greater, say 1.2 gallons an hour. With gasoline at 17 cents per gallon the hourly cost of fuel is 20.4 cents. The fuel cost of water is then 1.78 cents per 1,000 gallons, $0.000505, or one-twentieth of a cent per 1,000 foot-gallons, and $5.80 per acre-foot.

Mr. Houck gives the combined cost of the three pumping plants on the Horaco ranch as follows:

*Cost of pumping plants on Horaco ranch.*

| | |
|---|---|
| Three 12-horsepower Weber gasoline engines, three No. 5 Byron Jackson pumps with piping, belting, etc., all in place | $2,100.00 |
| Wells at $2.50 per foot | 475.00 |
| Well pits, buildings, flumes, etc., extra | 400.00 |
| | 2,975.00 |

Depreciation at 10 per cent and interest at 8 per cent amounts to $536 per annum. For an irrigation season of one hundred days this averages $5.36 per day, or $1.80 a day for each plant.

The hourly cost of plant No. 1 may be figured as follows:

*Hourly cost of pumping plant No. 1 at Horaco ranch.*

| | |
|---|---|
| Fuel (gasoline) | $0.16 |
| Interest and depreciation | .18 |
| Labor, lubricating oil, etc | .10 |
| Total | .44 |

The last item is based on the supposition that one man can run the three plants.

At well No. 1 the yield of water is 837 gallons a minute, or 50,220 gallons an hour. The cost is therefore $0.00876 per 1,000 gallons, or $2.85 per acre-foot.

The cost at the other plants is much greater on account of poorer wells. The wells would probably show little difference in capacity or cost of the water if they were all as deep as well No. 1. The coarse gravels were not reached at all in well No. 2, and were not penetrated in well No. 3.

Mr. Houck made a careful test of the amount of gasoline used at pumping plants Nos. 1 and 3 in November, 1904. Each of the engines at these plants ran sixteen hours on 16 gallons of gasoline. These tests are in substantial accord with the former tests quoted above, but show a slightly smaller quantity of gasoline consumed.

Plants Nos. 1 and 3 were used on two occasions to irrigate 25 acres of land, consisting of 21 acres of alfalfa and 4 acres of orchard and garden, and sixteen hours of continuous run were required at each trial. This is equivalent to about 2¼ inches of water per irrigation.

An interesting observation was made of the effect of stopping the pumps during the night instead of making a continuous run as above. When this was done the pumps had to be run two and one-half hours longer to irrigate land that had previously been irrigated in sixteen hours.

# APPENDIX.

## ANALYSES OF WELL WATER AND DATA CONCERNING WELLS AT AND NEAR EL PASO, TEX.

This information was furnished by Mr. A. Courchesne, of El Paso, Tex.

*Water in corral at stone quarry above El Paso, Tex.*

| Analysis. | Parts per 100,000. | Probable combinations. | Parts per 100,000. |
|---|---|---|---|
| Silica | 3.00 | Silica | 3.00 |
| Alumina | 2.00 | Alumina | 2.00 |
| Lime | 26.20 | Carbonate of lime | 34.00 |
| Magnesia | 6.11 | Sulphate of lime | 17.65 |
| Soda | 18.84 | Sulphate of magnesia | 18.30 |
| Carbonic acid | 15.00 | Sulphate of soda | 1.90 |
| Sulphuric acid | 23.70 | Chloride of sodium | 33.95 |
| Chlorine (Cl) | 20.60 | Water of crystallization, etc. | 1.20 |
| Water of crystallization, or loss | 1.20 | Total solids | 112.00 |
| | 116.65 | Total hardness | 62.20 |
| Oxygen equivalent to Cl | 4.65 | Permanent hardness | 28.20 |
| Total solids | 112.00 | | |

This is not a good boiler water, though most of the solids will come down as sludge instead of sticking to tubes. Still there is enough in combination to make a hard seal of sulphate of lime and carbonate of magnesia. The water will corrode, but not badly.

*Analysis of water from mile 211, El Paso and Southwestern Railroad.*

| Constituent. | Parts per 100,000. | Probable combination. | Parts per 100,000. |
|---|---|---|---|
| Silica | 7.00 | Silica | 9.00 |
| Alumina | 1.00 | Alumina | 1.00 |
| Lime | 6.70 | Carbonate of lime | 12.00 |
| Magnesia | 2.80 | Carbonate of magnesia | 3.62 |
| Soda | 16.40 | Sulphate of magnesia | 3.45 |
| Sulphuric acid | 13.65 | Sulphate of soda | 20.33 |
| Carbonic acid | 7.48 | Chloride of sodium | 14.35 |
| Chlorine (Cl) | 8.70 | Water of crystallization | .25 |
| Water of crystallization | 25 | Total solids | 62.00 |
| | 63.98 | | |
| Oxygen equivalent to Cl | 1.98 | | |
| Total solids | 62.00 | | |

This is a good locomotive water, and is a fairly good drinking water, very slightly medical from Glaubers salts.

*Water from 70-foot well at ranch of A. Courchesne, near Ysleta, Tex.*

| Constituent. | Parts per 100,000. |
|---|---|
| Silica | 3.00 |
| Alumina and phosphate | 10.00 |
| Carbonate of lime | 15.00 |
| Carbonate of magnesia | 3.01 |
| Carbonate of soda | 12.13 |
| Sulphate of soda | 7.80 |
| Chloride of sodium | 23.30 |
| Organic and water of crystallization | 1.76 |
| | 106.00 |

This water is comparatively soft and good for boiler use. It has too much organic matter in it for a safe drinking water. The dried solids blacken on ignition and smell badly. It is probably polluted with sewage.

*Water from lime quarry, El Paso, 30 feet deep.*

| Constituent. | Parts per 100,000. | Probable combinations. | Parts per 100,000. |
|---|---|---|---|
| Silica | 2.60 | Silica | 2.60 |
| Alumina | 2.00 | Alumina | 2.00 |
| Lime | 44.72 | Carbonate of lime | 32.00 |
| Magnesia | 10.80 | Sulphate of lime | 65.30 |
| Soda | 65.80 | Sulphate of magnesia | 32.40 |
| Sulphuric acid | 60.00 | Chloride of sodium | 124.20 |
| Carbonic acid | 14.00 | Water of crystallization | 27.50 |
| Carbonic | 75.60 | Total solids, 100 c | 286.00 |
| Water of crystallization | 27.50 | Total solids, grains per gallon (US) | 167.00 |
| | 303.02 | | |
| Oxygen equivalent to Cl | 17.02 | | |
| Total solids, 100 c | 286.00 | | |

This water is not good for drinking or boiler purposes. It will scale and corrode badly. It could be made usable for boilers by treatment with caustic and carbonate of soda, but it would not then be a good water on account of high proportions of common salt.

*Analyses of waters from wells of El Paso ice plant.*

| Constituent. | Surface water. | 300-foot well (grains per U. S. gallon). | 80-foot well (grains per U. S. gallon.) |
|---|---|---|---|
| Organic | 5.4 | 3.033 | 5.249 |
| Silica | 2.8 | | 1.166 |
| Sulphate of lime | | | 35.003 |
| Carbonate of lime | 26.3 | 9.580 | 10.940 |
| Carbonate of magnesia | 5.3 | 1.102 | .883 |
| Chloride of sodium | 36.9 | 6.102 | 52.464 |
| Chloride of lime | | | 4.391 |
| Chloride of magnesia | | | 9.802 |
| Sulphate of magnesia | | | 5.148 |
| Sulphate of sodium | 32.5 | 7.407 | |
| Carbonate of sodium | 5.2 | | |
| Iron and alumina | .6 | | |
| Total solids | 115.0 | 27.224 | 125.046 |
| Incrustants | 34.9 | 10.682 | 47.992 |
| Corroding salts | | | 19.341 |
| Rating for boiler purposes | Bad. | Good. | Very bad. |

*Analysis from water from new 400-foot well of El Paso Ice and Refrigerator Company, El Paso, Tex.*

| Constituent. | Parts per 100,000. | Probable combinations. | Parts per 100,000. |
|---|---|---|---|
| Silica | 0.50 | Silica | 0.50 |
| Alumina | Tr. | Alumina | Tr. |
| Lime | 2.23 | Carbonate of lime | 4.00 |
| Magnesia | 3.00 | Carbonate of magnesia | 6.30 |
| Soda | 8.98 | Carbonate of soda | 1.59 |
| Chlorine | 5.31 | Sulphate of soda | 7.90 |
| Carbonic acid | 5.72 | Chloride of sodium | 8.71 |
| Sulphuric acid | 4.45 | Total solids | 29.00 |
| | 30.19 | Total hardness | 11.5 |
| Oxygen equivalent to Cl | 1.19 | | |
| Total solids | 29.00 | | |

This is a good water. The hardness is rather high, but it is temporary, and only a small part (about 20 per cent) will incrust, the rest falling as slugs in the boiler, which can be blown out.

*Analysis of El Paso well water.*

| Constituent. | Grains per U. S. gallon. |
|---|---|
| Incrusting solids: | |
| Calcium carbonate | 3.20 |
| Calcium sulphate | None. |
| Calcium chloride | None. |
| Magnesium carbonate | 1.39 |
| Magnesium sulphate | None. |
| Magnesium chloride | None. |
| Iron and alumina | .07 |
| Silica | 1.61 |
| Suspended matter | Trace. |
| Total | 6.27 |
| Nonincrusting solids: | |
| Sodium sulphate | 5.82 |
| Sodium chloride | 7.02 |
| Sodium carbonate | 4.19 |
| Total | 17.03 |
| Alkalinity | 9.33 |
| Hardness | 5.26 |
| Carbonic acid | 2.42 |
| Pounds of incrusting solids per thousand gallons | .90 |

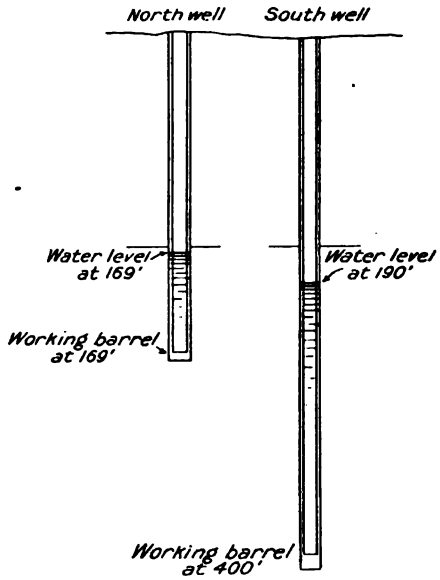



FIG. 32.—Wells at Fort Bliss station, El Paso and Northeastern Railroad.

*Data concerning wells at Fort Bliss*

NORTH WELL.

Completed: July 22, 1901.
Total depth: 249 feet.
Casing: 249 feet of 6-inch.
Depth of working barrel: 245 feet.
Water level: 169 feet below earth's surface.
Pump: 12 by 36 inches, Cook.
Tested capacity of well: 80,000 gallons per twenty-four hours.

SOUTH WELL.

Completed: 1901.
Total depth: 410 feet.
Casing: 410 feet of 6-inch.
Depth of working barrel: 400 feet.
Water level: 190 feet below earth's surface.
Pump: 10 by 36 inches, Cook.
Tested capacity of well: 30,000 gallons per twenty-four hours.

FEATURES COMMON TO NORTH AND SOUTH WELLS.

Contractor: William McLease.
Size of hole: 8 inches.
Pump column: 6-inch standard.
Working barrel: 5½-inch, Cook.
Well rods: No. 3; 3-inch hickory, 1½-inch straight pins.
Storage: 50,000 gallons, wooden tank.
Boiler: 30 horsepower, Economic.

*Analysis of Fort Bliss well water.*

| Constituent. | Grains per U. S. gallon. |
|---|---|
| Calcium carbonate (incrusting) | 4.90 |
| Magnesium carbonate (incrusting) | 3.09 |
| Silica (incrusting) | 1.34 |
| Oxides, alumina and iron (incrusting) | .06 |
| Alkali carbonates (nonincrusting) | 2.74 |
| Alkali sulphates (nonincrusting) | 2.62 |
| Alkali chlorides (nonincrusting) | 1.63 |
| Alkali nitrates (nonincrusting) | .70 |
| Sulphates, lime, and magnesium | Traces. |
| Total incrusting solids | 9.39 |
| Total nonincrusting solids | 7.69 |
| Pounds incrusting matter per 1,000 gallons | 1.34 |
| Pounds nonincrusting matter per 1,000 gallons | 1.09 |

This water should be classed as good.

# INDEX.


Page.

Agricultural College, pumping plants at, data concerning..... 34-37, 65-67
pumping plants at, section of, diagram showing..... 66
wells of..... 22
Alkali. *See* Salts.
Barker, L. C., pumping plant of, data concerning..... 31, 34-38, 51-53
pumping plant of, section through, diagram showing..... 52
reservoir of..... 38
well of, water of, analysis of..... 20
Berino, N. Mex., cross section at, diagram showing..... 30
pumping plants near, data concerning. 67-73
water horizon at..... 30
wells near..... 30
water of, analyses of..... 20
Boyer, Mrs. E. M., pumping plant of, data concerning..... 31, 34-36, 38, 56-58
pumping plant of, section through, diagram showing..... 57
well of..... 24
water of, analysis of..... 20
Burke, F., pumping plant of, data concerning..... 31, 34-38, 53-56
pumping plant of, section through, diagram showing..... 55
Caliche, occurrence and character of..... 15-17
California well rig, view of..... 16
Carrera, J. C., pumping plant of, data concerning..... 31, 34-36, 38, 53
pumping plant of, section through, diagram showing..... 54
well of, water of, analysis of..... 20
Chlorine in Rio Grande water, quantity of. 12-13
quantity of, variation in, diagram showing..... 12
Courchesne, A., analysis furnished by..... 74
well of, water of, analysis of..... 75
Depth, variations of salts in water with... 12
El Paso, ground water near..... 14-21
ground water near, analyses of..... 74-79
narrows at, cross section of..... 11
map of..... 10
pumping plants near..... 39-51
sections through, diagrams showing..... 40, 42, 44, 45, 48, 49
quarry at, water of, analysis of..... 74, 76

Page.

El Paso, rainfall at..... 21
Rio Grande near, view of..... 10
section near, diagram showing..... 16
underflow near..... 9-13
wells at and near, location of, map showing..... 15
water of, analyses of..... 20, 74-79
El Paso and Northeastern Railroad, well of, water of, analysis of..... 20
El Paso and Southwestern Railroad, well of, water of, analysis of..... 75
El Paso Brewery, well of, water of, analysis of..... 20
El Paso Ice and Refrigerator Company, well of, water of, analysis of..... 77
Electrolytes, use of..... 12
Floods, occurrence of..... 25, 30
Fort Bliss Military Reservation, wells of... 17-18
wells of, section of, diagram showing.. 78
water of, analyses of..... 20, 78-79
French, W. N., pumping plant of, data concerning..... 31, 34-36, 38, 41-43
pumping plant of, section through, diagram showing..... 41
well of..... 18
section through, diagram of..... 16
water of, analysis of..... 20
Fuel, cost of..... 33
Ground water, amount of..... 28-29
at Berino..... 30
below El Paso..... 14-21
in Mesilla Valley..... 22-29
level of, variation in, diagram showing. 26
origin of..... 17-18, 22, 25-28
salts in, variation in, diagram showing. 12
velocity of..... 9
Gypsum, occurrence of..... 14
Hadlock, E. J., pumping plant of, data concerning..... 31, 34-36, 39-41
wells of, analysis of..... 20
arrangement of, diagram showing. 39
location of, figure showing..... 30
water in, elevation of, figure showing..... 40
Hager, W. N., pumping plant of, data concerning..... 31, 34-38, 58-59
pumping plant of, section through, diagram showing..... 58
well of, water of, analysis of..... 20

Page.
Hereford, section at, diagram showing .... 16
soil near .... 17
Hines, A. L., pumping plant of, data concerning .... 31, 34–38, 59–61
pumping plant of, section through, diagram showing .... 60
well of, water of, analysis of .... 20
Horaco Ranche Company, pumping plants of, data concerning .... 31, 34–35, 37–38, 67–73
pumping plants of, sections through, diagrams showing .... 68, 70, 71
view at .... 62
wells of .... 30
water from, analyses of .... 20
International Water Supply Company, wells of .... 18
Lanoria Mesa, location and character of .... 14
section through, diagram of .... 16
Las Cruces, N. Mex., floods at .... 25
irrigation at and near .... 22
pumping plants near .... 31, 36–37, 51–67
sections through, diagrams showing .... 52, 54, 57
underflow near .... 22
wells near, water of, analyses of .... 20
Lava, occurrence of .... 14
Lost River, location of .... 14
Map showing location of wells and pumping plants near El Paso .... 12
showing location of wells near Mesilla Park .... 23
Martinez, Felix, pumping plant of, data concerning .... 31, 34–36, 38, 43–45
pumping plant of, section through, diagram showing .... 44
well of, water of, analysis of .... 20
Mesilla, N. Mex., pumping plants near .... 31, 34–38, 58–61, 64–65
pumping plants near, sections through, diagrams showing .... 58, 60
Mesilla Park, ground water at .... 26–27
pumping plants near .... 31, 34–38, 53–56, 65–67
sections through, diagrams showing .... 55, 66
wells near, location of, map showing .... 23
Mesilla Valley, ground water in .... 22–31
irrigation at and near .... 22
pumping plants in .... 22, 37, 51–67
sections of, diagrams showing .... 55, 58, 60, 63, 66
underflow in .... 22
wells in .... 22–24, 29
Mexican-American international dam, location of .... 9
*See also* Narrows.
Narrows of Rio Grande, cross section at .... 9, 13
cross section at, diagram showing .... 11
data concerning .... 9–13
map of .... 10
underflow at .... 9–13
analyses of .... 20
salts in, variation in, diagram showing .... 12
view of .... 10
New Mexico, southern, pumping plants in .... 31–38

Page.
Porcher, J. S., pumping plant of, data concerning .... 31, 34–36, 38, 50–51
pumping plant of, section through, diagram showing .... 49
water plane at, elevation of, figure showing .... 19
wells of, water of .... 18–19, 2.
analysis of .... 20
Porcher strainer, view of .... 16
Pumping plants, fuel cost of .... 33
location of, map showing .... 15
operating cost of .... 32–33
specific capacity of .... 32, 36–37
tests of .... 39–73
vacuum of, determination of .... 31–32
*See also individual plants.*
Rainfall, amount of .... 17, 21, 22
Reservoirs, storage, necessity for .... 38
Rigs, well, views of .... 16, 20
Rio Grande, floods on .... 25, 30
narrows of, cross section of .... 11
map of .... 10
view of .... 10
seepage from .... 21, 28–29
underflow of, at Narrows .... 9–13
near Mesilla Park .... 29
valley of, cross section of, figure showing .... 30
water of .... 10–11, 21
analysis of .... 20
salts in, variation in, diagram showing .... 12
water plane near, elevation of, diagram showing .... 19
wells along .... 18
water from, analyses of .... 20
Roualt, T., pumping plant of, data concerning .... 31, 34–38, 61–64
pumping plant of, section through, diagram showing .... 62
well of, water of, analysis of .... 20
Sacramento Mountains, location of .... 14
timber on, view of .... 20
Salts, in Rio Grande underflow .... 11–12
in Rio Grande underflow, quantity of, variation in, diagram showing .... 12
in wells .... 14
Silt, layers of .... 13
Smith, J. A., pumping plants of, data concerning .... 31, 34–36, 38, 45–49
pumping plants of, sections through, diagrams showing .... 45, 48
view of .... 62
water plane at, elevation of, diagram showing .... 19
wells of, water of, analyses of .... 20
Southern Pacific Railroad, wells of .... 17
wells of, water of, analyses of .... 20
Specific capacity, determination of .... 32
*See also individual plants.*
Test wells at narrows, use of .... 12, 23–24
water of, analyses of .... 20
elevation of, diagram showing .... 24
test well in Mesilla Valley .... 24–25
water level in, variation of, diagram showing .... 26
Texas, trans-Pecos, pumping plants in .... 31–38

Page.
Tinsley, J. D., aid of ..... 25
Totten, G. H., pumping plant of, data concerning..... 31, 34-38, 64-65
pumping plant of, section through, diagram showing..... 63
well of, water of, analysis of ..... 20
discharge of, parabola of, diagram showing..... 65
Underflow at narrows..... 9-13
at narrows, velocity of ..... 9, 12-13
salts in ..... 11-12, 14
source of..... 25-28
*See also* Ground water.
Vacuum, determination of..... 31-32
Water, ground. *See* Ground water.

Page.
Water horizon, depth to and location of... 14-15, 22, 24-25, 30
position of, diagrams showing..... 19, 24, 30
Well rigs, views of..... 16, 20
Wells, depth of..... 29
location of..... 14, 17-18, 22
maps showing..... 15, 23
water of, analyses of..... 22
*See also individual wells and pumping plants.*
Wells, deep, need of..... 29
Wells, test. *See* Test wells.
White sands. *See* Gypsum.
Wood, cost of..... 33
Ysleta, Tex., well near, water of, analysis of. 75

O

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WS 141. Observations on the ground waters of the Rio Grande Valley, 1904, by C. S. Slichter. 1905. 83 pp., 5 pls.

The following papers also relate to this subject: Underground waters of Arkansas Valley in eastern Colorado, by G. K. Gilbert, in Seventeenth Annual, Pt. II; Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton, in Seventeenth Annual, Pt. II; Water resources of Illinois, by Frank Leverett, in Seventeenth Annual, Pt. II; Water resources of Indiana and Ohio, by Frank Leverett, in Eighteenth Annual, Pt. IV; New developments in well boring and irrigation in eastern South Dakota, by N. H. Darton, in Eighteenth Annual, Pt. IV; Rock waters of Ohio, by Edward Orton, in Nineteenth Annual, Pt. IV; Artesian well prospects in the Atlantic coastal plain region, by N. H. Darton, Bulletin No. 138.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

SEPTEMBER 1905.

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Author.

**Slichter, Charles S[umner] 1864–**

. . . Observations on the ground waters of Rio Grande Valley, by Charles S. Slichter. Washington, Gov't print. off., 1905.

83, iii p. illus., V pl., diagrs. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 141)

Subject series: K, Pumping water, 11; O, Underground waters, 44.

Appendix: Analysis of well water and data concerning wells at and near El Paso, Texas.

1. Water, Underground—Texas. 2. Water, Underground—New Mexico.

Subject.

**Slichter, Charles S[umner] 1864–**

. . . Observations on the ground waters of Rio Grande Valley, by Charles S. Slichter. Washington, Gov't print. off., 1905.

83, iii p. illus., V pl., diagrs. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 141)

Subject series: K, Pumping water, 11; O, Underground waters, 44.

Appendix: Analysis of well water and data concerning wells at and near El Paso, Texas.

1. Water, Underground—Texas. 2. Water, Underground—New Mexico.

Series.

**U. S. Geological survey.**

Water-supply and irrigation papers.

no. 141. Slichter, C. S. Observations on the ground waters of Rio Grande Valley. 1905.

Reference.

**U. S. Dept. of the Interior.**

see also

**U. S. Geological survey.**

Water-Supply and Irrigation Paper No. 142 Series O, Underground Waters, 45

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

# THE HYDROLOGY OF SAN BERNARDINO VALLEY, CALIFORNIA

BY

WALTER C. MENDENHALL

WASHINGTON
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1905

# CONTENTS.


| | Page |
|---|---|
| Letter of transmittal | 7 |
| Introduction | 9 |
| Geographic situation | 9 |
| Settlement | 10 |
| Development of irrigation | 10 |
| Bibliography | 13 |
| Rainfall | 15 |
| Soils | 20 |
| Water supply | 23 |
| Effect of forests | 23 |
| Return waters | 26 |
| San Bernardino artesian area | 29 |
| Origin of San Bernardino basin | 30 |
| Depth of the basin | 31 |
| General classes of rocks | 32 |
| Alluvial fans | 35 |
| Well records | 38 |
| The cienaga | 47 |
| Underground circulation | 48 |
| Origin of head within the artesian belt | 52 |
| Decline of the waters | 56 |
| Other artesian areas | 67 |
| Yucaipe basin | 67 |
| Riverside basin | 70 |
| Ground waters | 71 |
| Temperatures | 72 |
| Chemical character of the waters | 76 |
| Tables of flow | 79 |
| Mill Creek | 79 |
| Santa Ana River | 81 |
| Plunge Creek | 83 |
| City Creek | 83 |
| East Twin Creek | 84 |
| West Twin Creek | 84 |
| Lytle Creek | 85 |
| Canals above Colton | 86 |
| List of wells | 87 |
| Wells in Redlands quadrangle | 88 |
| Wells in San Bernardino quadrangle | 100 |
| Index | 119 |

# ILLUSTRATIONS.


| | | Page. |
|---|---|---|
| PLATE I. | Outline map of southern California | 8 |
| II. | *A*, Riverside-Highlands irrigation district; *B*, Baldwin Lake | 12 |
| III. | View of the West Riverside district | 14 |
| IV. | View of East Riverside mesa and Santa Ana Valley | 16 |
| V. | Redlands and San Bernardino and San Gorgonio peaks | 20 |
| VI. | *A*, Later alluvium exposed along the edge of East Riverside mesa; *B*, The later alluvial fan about Kenwood | 34 |
| VII. | Map showing changes in artesian areas and water levels in the San Bernardino basin | Pocket. |
| VIII. | Artesian areas in the valley of southern California | Pocket. |
| IX. | View of San Timoteo Canyon and the northward-dipping earlier alluvium | 68 |
| X. | *A*, Yucaipe Valley and artesian lands; *B*, Nonartesian water-bearing lands in Santa Ana Valley | 70 |
| XI. | The Bunker Hill dike | 72 |
| XII. | Hydrologic map of San Bernardino, Redlands, and vicinity, showing irrigated lands | Pocket. |
| FIG. 1. | Chart showing variation from average rainfall at San Bernardino, Cal. | 19 |
| 2. | Approximate section across San Bernardino Valley along the line A–B, Pl. XII | 32 |
| 3. | Diagrammatic longitudinal section of alluvial fan | 36 |
| 4. | Section of the Bucher well | 38 |
| 5. | Well sections along line A–B, Pl. XII | 40 |
| 6. | Well sections along line E–F, Pl. XII | 42 |
| 7. | Section of the South Mountain Water Company's deep well in Yucaipe Valley | 43 |
| 8. | Section of Frink Brothers' well in Yucaipe Canyon | 44 |
| 9. | Well sections along line G–H, Pl. XII | 45 |
| 10. | Diagrammatic cross section of summer and winter water table beneath a stream channel | 49 |
| 11. | Diagram showing sinking of flood waters of Santa Ana River in stream bed | 52 |
| 12. | Chart showing variation of water level in Williams well | 60 |
| 13. | Chart showing variation of water level in Johnson well, near San Bernadino | 62 |
| 14. | Chart showing variation of water level in Neff well, near Anaheim | 63 |
| 15. | Approximate section across the Crafton Hills and Yucaipe Valley along the line C–D, Pl. XII | 68 |
| 16. | Diagrammatic cross section of drained prism in alluvial-fan material | 72 |

# LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
*Los Angeles, Cal., February 16, 1905.*

SIR: I transmit herewith the manuscript of a report on the hydrology of the San Bernardino Valley, California, and recommend that it be published as a water-supply paper. This report has been prepared by Mr. W. C. Mendenhall, geologist, under the general direction of Mr. N. H. Darton. It is one of a series of reports on the underground waters of the valley of southern California.

In this valley, where irrigation practice has attained a high degree of perfection, the underground waters are of very great importance, two-thirds of the irrigated acreage being dependent upon them either wholly or in part.

In this paper those phases of the geology which throw light upon the amount, distribution, and movements of these waters are described, and the effects of development and drought in bringing about those changes in water levels which have taken place in recent years are discussed.

The author has had constantly in mind, in the preparation of the paper, the needs of the practical irrigator and the questions which must arise in disputes concerning title to percolating waters.

Very respectfully,

F. H. NEWELL, *Chief Engineer.*

Hon. CHARLES D. WALCOTT,
*Director United States Geological Survey.*

38
37
36
35
34
33

# HYDROLOGY OF SAN BERNARDINO VALLEY, CALIFORNIA.

By WALTER C. MENDENHALL.

## INTRODUCTION.

### GEOGRAPHIC SITUATION.

The San Bernardino basin lies near the eastern end of the valley of southern California. Under the latter term is included that general lowland area which is definitely limited on the north by the San Gabriel and San Bernardino ranges and on the east by the latter range and the San Jacinto group, but whose southern boundary is irregular and difficult to define. In this direction there is an interdigitation of ridges and valleys as the Sierra Madre Range of San Diego County dies out toward the north. The more or less indefinite heights that represent its extension in this direction are separated by lowlands, which in turn are to be regarded as southwest lobes of the well-defined east-west valley that lies along the base of the San Gabriel Range.

Toward the west this greater valley opens directly to the Pacific, without the intervention of any extensive heights. The Santa Ana Mountains and the San Jose Hills project well into it from the southeast, at a distance of about 25 miles from the Pacific shore line, in the vicinity of Lordsburg, and reduce its width at this point to but a few miles. The San Gabriel basin and the coastal plain, separated by the low Los Angeles and Puente hills, lie west of this ridge. East of it are the Cucamonga and Chino plains, the Riverside basin, the numerous more or less isolated valleys of the upper San Jacinto drainage area, and the San Bernardino basin, which together form an interior subdivision of the greater valley. The San Bernardino basin is the northeastern part of this interior subdivision, and from the point of view of water supply is most important. It is separated on the east and south from the adjacent lowlands by the Crafton Hills, the ridge known as the Badlands, and the Jurupa Mountains. Toward the west it opens directly into the wide Cucamonga plains. It lies wholly within the valley portion of San Bernardino County and forms a part of the drainage basin of Santa Ana River, all of the streams which flow down

into it from the San Bernardino and San Gabriel mountains being tributaries of this, the most important stream in southern California.

### SETTLEMENT.

When in 1851 the first band of Mormon immigrants, led by Captain Hunt, descended through Cajon Pass into San Bernardino Valley, after a journey of months across the parched deserts from Salt Lake, the abundant springs of pure water and the living streams in the great cienaga must have appealed to them with a force which was greatly increased by the vivid memory of the loss of their companions by thirst in Death Valley but a short time before. It is not a matter of wonder that they decided that their wanderings should cease here and that forthwith they began the building of homes, in which they hoped to spend the rest of their lives.

As early as 1810 a mission settlement had been made at Politana, near what is now Bunker Hill, and somewhat later another of more importance and greater permanence was established at old San Bernardino, on the south side of Santa Ana River. Politana was destroyed by the Indians and abandoned soon after its foundation, but the San Bernardino branch mission flourished, and under the direction of the church fathers in charge there the Mill Creek zanja, the oldest irrigation ditch in the valley, was constructed between 1820 and 1830. When the missions were secularized by command of the Mexican Government in 1833, and their lands distributed to Mexican citizens by large grants, the San Bernardino rancho, which included nearly all of the cultivable lands of the valley, fell to members of the Lugo family, and from them it was purchased by the Mormon settlers in 1851 for $7,500.

### DEVELOPMENT OF IRRIGATION.

When the Mormons came into possession, the Mill Creek zanja at old San Bernardino was the only irrigating work in this part of California. The wide area of moist lands above Colton, the limited numbers, the simple needs, and the pastoral habits of the first settlers, all combined to reduce the necessity for irrigation, so that the first ditch of their own building was not constructed until 1854. With this beginning, other small ditches were dug in the middle of the valley as the population slowly increased and the irrigated areas were gradually extended, but extensive projects were not undertaken until work was begun upon the first Riverside canal by a New England colony, the Silk Center Association, in 1870. By 1876 both the upper and lower Riverside canals had been completed, and thereafter a constantly increasing acreage was brought under cultivation by the water furnished by them, until in 1882 4,300 acres were reported as supplied by these systems, which at that time depended upon the flowing waters of Warm Creek and Santa Ana River.

During this period the waters from other streams tributary to San Bernardino Valley were diverted and utilized upon the available lands. City Creek water had at first been applied only to the lower lands, to which it could be most easily conducted; but in 1874 a canal was constructed by which it was taken to the "bench" lands in the vicinity of what is now Highlands. The superior value of the bench lands even at this early date was rapidly coming to be recognized.

The Highlands ditch, by which the waters of Santa Ana River were first taken out upon the East Highlands mesa, was built in 1881 and 1882.

In 1883 the construction of the Bear Valley dam was begun, and with its completion in 1884 the reclamation of the valuable citrus lands of the Redlands mesa was accomplished. The success of this project was marred by bad financiering and by a serious overestimate of the amount of water which it would render available, so that although it brought into the productive zone a large acreage of fertile lands which were useless before its completion, these positive gains were accompanied by serious losses.

The tendency constantly observable throughout this period was to extend cultivation to higher ground. The first canals had served only the lowest lands adjacent to the river bottoms; but these lands, subject as they were to frost, proved to be not so well adapted to the valuable citrus fruits as the warmer benches. Encouraged by the success of the earlier projects and recognizing the growing value of the mesas, Matthew Gage, in 1885, undertook the construction of a higher canal from which it was proposed to irrigate a belt of the Riverside mesa lying entirely above the older Riverside canal systems. The Gage canal was constructed in sections and was finally completed to its present terminus in 1888. Unlike the other large canals of San Bernardino Valley, it has depended from the first chiefly upon developed underground waters, and the 7,500 acres of splendid citrus lands which it has brought into the productive zone indicate the results that may be accomplished by the use of such waters.

Since the completion of the Gage system other projects have been put through, but development has been less rapid since the early eighties, partly because the available water supplies were generally utilized in the projects which had been developed by that time and partly because the unfavorable commercial conditions prevailing during the early nineties made investors generally much more conservative.

Among the later developments worthy of note are those of the Riverside Highlands Water Company, organized in 1898, whose latest plant for the supply of the higher parts of the old East Riverside district was installed in 1904. The final result of all of this development has been the reclamation of about 54,000 acres in the Redlands, San Bernardino, and Riverside quadrangles. Nearly all of this acreage

depends upon the water supply from the San Bernardino Mountains. either utilized directly as it flows from the canyons or recovered later from underground reservoirs.

By tracing in this incomplete review the development of the irrigation projects within the valley from the time when only the low-lying lands within reach of the old Mill Creek zanja, constructed by the Mission fathers, or those in the moist bottoms which needed no artificial watering, or only such as could be given by the simplest of ditches, were utilized, to the later periods when the superior value of the bench lands came gradually to be recognized and costly and carefully designed irrigation works were planned for their redemption. we gain some comprehension of the constantly increasing demand for water and its concurrently increasing value.

The most important single element in bringing about this development has been the growth of the citrus industry since the foundation of the Riverside colony in 1870. The first citrus trees were probably some seedling oranges grown about old San Bernardino rather as ornamental trees than because they were conceived to be of commercial value. Indeed, before the building of the transcontinental railway lines, which gave the fruit a wide market, they could be of but little importance, since local consumption has never been sufficient to provide a profitable market. In the Riverside colony, however, citrus trees were planted early as a commercial venture, and from a modest beginning there, down on the lower lands under the old Riverside canal, the groves have gradually crept up the slopes to the warm, fertile, frostless soils of the mesa (Pl. II, *A*) until now these lands wherever cultivated are producing the best fruits of the district.

The steady increase of acreage under the various systems and the increasing maturity of the groves first planted have called for constant extensions of the irrigating systems. With the increase in acreage there has gone a constant improvement in irrigation practice and in methods of cultivation, so that the amount of water in use for citrus orchards has diminished from 1 miner's inch for each 3 acres to 1 inch for 5 or 6 acres, and many successful horticulturists maintain that even this diminished amount may be reduced not only without harm but with positive benefit to the soils and groves. The improvement in practice which has already taken place means that the amount of water used for irrigation has by no means increased as rapidly as the area cultivated, yet there has been a slow general increase, as the following table will show.

*A.* RIVERSIDE-HIGHLANDS IRRIGATION DISTRICT.

*B.* BALDWIN LAKE.

United States Geological Survey, and readers are referred to it for details of the organization of companies operating along the northern and eastern edges of this valley, and for descriptions of the engineering features of interest there.

A later paper by Mr. Lippincott, entitled "Development and Application of Water near San Bernardino, Colton, and Riverside, Cal.," has been issued in two parts, as Water-Supply Papers Nos. 59 and 60, of the United States Geological Survey. This paper includes the results of Mr. Lippincott's studies in the lower, western, and southern parts of the basin and the contiguous regions. In it, as in the earlier paper, particular attention is paid to the surface supplies, to engineering features, and to the organization and operation of districts and water-distributing corporations.

Results of measurements of stream flow made by Mr. Lippincott in his capacity of resident hydrographer of the Geological Survey, or by his assistants, have appeared from time to time in the progress reports of the division of hydrography, and these have been assembled with similar data from other parts of California in a volume entitled "California Hydrography," issued by the Geological Survey in 1903, as Water-Supply Paper No. 81. This volume includes the measurements of the year 1902.

The United States Department of Agriculture has issued, as a reprint from its Office of Experiment Stations Bulletin No. 9, a volume entitled "Report of Irrigation Investigations for 1901," which includes a valuable paper by Prof. E. W. Hilgard on the "Subterranean Water Supply of the San Bernardino Valley." Professor Hilgard has conducted investigations in San Bernardino Valley at several periods, and has paid particular attention to the supply of the Gage Canal Company. By cooperating closely with the engineers of this organization he has assembled a body of facts which have unique value in a study of the underground waters, and will have increasing value as they are augmented by accumulating data.

In the same volume is a paper by the late William Irving, engineer of the Gage Canal Company, on the "Duty of Water under the Gage Canal, 1901." This paper is one of a series issued by Mr. Irving, in which the duty is discussed for the years 1899, 1900, and 1901, the earlier papers appearing in Bulletins Nos. 86 and 104 of the Department of Agriculture, Office of Experiment Stations.

In addition to these papers issued by experts from one or another of the departments of our Government, many scattered data upon particular phases of the question of water supply are to be found in the court records, as a part of the the testimony introduced in the numerous suits which have been filed from time to time.

VIEW OF THE WEST R

VERSIDE DISTRICT

per cent above the average, so that a more nearly correct figure may be obtained if it is reduced by one-half, yet with this liberal reduction it is nearly double the valley records, and thus illustrates the much heavier precipitation at the mountain tops.

*Rainfall records, Colton, Cal.*

| Year. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | Rainfall for season. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1877 | ..... | ..... | ..... | ..... | ..... | ..... | 1.64 | T. | 1.72 | 1.00 | 1.58 | 0.00 | 5.94 |
| 1877-78 | 0.00 | 0.00 | 0.00 | 0.07 | 0.35 | 1.93 | 1.94 | 5.16 | 1.38 | 2.99 | .71 | .00 | 14.53 |
| 1878-79 | .00 | .00 | .00 | .24 | .30 | 1.68 | 1.79 | .74 | .03 | 1.75 | .10 | .08 | 6.71 |
| 1879-80 | .00 | .00 | .00 | .13 | 1.15 | 2.49 | .99 | .76 | 1.05 | 2.19 | .00 | .00 | 8.76 |
| 1880-81 | .00 | .00 | .00 | .13 | .27 | 2.37 | .74 | .90 | 1.39 | .28 | .00 | .00 | 6.08 |
| 1881-82 | .00 | .00 | .00 | .28 | .38 | .00 | 2.23 | 1.28 | 1.51 | 1.08 | .00 | .50 | 7.[illegible] |
| 1882-83 | .50 | .00 | .00 | .50 | .19 | .30 | .52 | 1.72 | 1.00 | .45 | .75 | .00 | 5.93 |
| 1883-84 | .00 | .00 | .00 | .60 | .00 | 2.23 | 1.00 | 11.38 | 4.05 | 2.85 | 2.90 | .32 | 25.33 |
| 1884-85 | .00 | .25 | .00 | .25 | .12 | 3.93 | 1.00 | .00 | .00 | 2.08 | .22 | .00 | 7.8[illegible] |
| 1885-86 | .00 | .00 | .00 | .00 | 1.92 | .52 | 2.78 | .40 | 3.54 | .50 | .00 | .00 | [illegible] |
| 1886-87 | .00 | .00 | .00 | .00 | .80 | .00 | .21 | 3.64 | .00 | 1.94 | T. | .00 | 6.[illegible] |
| 1887-88 | .00 | .00 | .00 | .00 | .70 | .80 | 4.89 | .42 | 3.68 | .43 | .00 | .00 | 10.92 |
| 1888-89 | .00 | .00 | .00 | .00 | 2.37 | 3.26 | .86 | .88 | 4.47 | 1.02 | .60 | .00 | 13.46 |
| 1889-90 | .00 | T. | .04 | 1.59 | 1.26 | 7.41 | 2.94 | 1.15 | .50 | .00 | .00 | .00 | 14.89 |
| 1890-91 | .00 | .06 | .67 | .00 | .19 | 2.45 | .00 | 6.48 | .25 | .80 | .90 | .00 | [illegible] |
| 1891-92 | .00 | .00 | .00 | .00 | .00 | .87 | 2.27 | 3.36 | .80 | .24 | 1.44 | .00 | [illegible] |
| 1892-93 | .00 | .00 | .00 | (.48) | .90 | 1.45 | 2.40 | 2.91 | 6.64 | .16 | .00 | .00 | 15.14 |
| 1893-94 | .30 | .00 | .00 | 1.18 | .22 | 1.93 | .20 | .55 | 2.00 | .10 | .50 | .00 | [illegible] |
| 1894-95 | .00 | .00 | .45 | .15 | .00 | 5.70 | 6.88 | 1.01 | 2.94 | 1.08 | 1.05 | .00 | 19.[illegible] |
| 1895-96 | .00 | .00 | .00 | .00 | 1.16 | .00 | 1.10 | .00 | 2.91 | .25 | .38 | .00 | [illegible] |
| 1896-97 | .00 | .10 | (.06) | 2.28 | .94 | 1.11 | 3.52 | 3.96 | 2.70 | .00 | .15 | .85 | 15.67 |
| 1897-98 | .00 | .00 | .00 | 2.20 | (.66) | .30 | 1.48 | .23 | .80 | .10 | .34 | .00 | 6.1[illegible] |
| 1898-99 | .00 | .00 | .00 | T. | T. | .45 | 1.57 | .45 | 1.55 | .00 | .00 | T. | 4.02 |
| 1899-1900 | .00 | .00 | .00 | .00 | 1.96 | .55 | 1.06 | .00 | .95 | 1.59 | .89 | .00 | 7.00 |
| 1900-1901 | .00 | .00 | T. | .32 | 6.47 | .00 | 3.44 | 4.28 | .08 | .00 | 1.00 | .00 | 15.59 |
| 1901-2 | .00 | .00 | .00 | 1.18 | .23 | .00 | .70 | 2.77 | 3.07 | 2.56 | .00 | .00 | 10.51 |
| 1902-3 | .00 | .00 | .00 | .15 | .97 | 1.66 | 1.42 | 1.60 | 5.51 | 4.37 | .00 | .00 | 15.68 |
| 1903-4 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1.60 | 4.40 | .82 | T. | ..... | [illegible] |

Average, 27 seasons, 10.63 inches.

The practical effect of the low rainfall over the valley lands is that only those crops which grow rapidly and mature quickly can be raised successfully without irrigation. Barley and oats for hay and grain are the principal crops successfully cultivated, and during unusually dry periods the grain may fail to mature and even the hay prove only a partial crop. Some vineyards in the sandy lands, an occasional small grove of olive trees, and a few apricots are also cultivated without the artificial application of water, but much the greater portion of the acreage cultivated, and all of the more valuable lands, are under irrigation.

VIEW OF EAST RIVERSIDE MI

ESA AND SANTA ANA VALLEY.

*Rainfall records, Redlands, Cal.*

| Year. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | Rainfall for season. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1889 | ..... | ..... | ..... | ..... | ..... | ..... | 0.68 | 1.47 | 5.70 | 0.99 | 0.58 | 0.00 | 9.42 |
| 1889-90 | 0.00 | 0.28 | 0.31 | 1.50 | 0.52 | 13.72 | 4.69 | 3.08 | .89 | .16 | .68 | .00 | 25.78 |
| 1890-91 | .00 | 2.16 | .88 | .29 | .00 | 3.02 | .00 | 9.28 | 1.19 | .91 | 1.10 | .23 | 19.06 |
| 1891-92 | .00 | 1.63 | .97 | .00 | .00 | 1.51 | .87 | 4.37 | 2.06 | .13 | .00 | .00 | 11.54 |
| 1892-93 | .00 | .00 | .03 | .00 | .63 | 1.58 | 3.02 | 3.98 | 7.22 | .26 | .00 | .00 | 16.67 |
| 1893-94 | .21 | .00 | .69 | .95 | .50 | 3.46 | 1.43 | 1.04 | 1.01 | .25 | .64 | .00 | 10.18 |
| 1894-95 | .00 | .09 | .17 | .07 | .00 | 7.38 | 8.66 | 1.30 | 3.29 | 1.37 | .57 | .00 | 22.90 |
| 1895-96 | .00 | .00 | .00 | .08 | 2.08 | .52 | 1.52 | .24 | 3.96 | .01 | 1.14 | .06 | 7.51 |
| 1896-97 | .01 | .00 | .00 | 1.72 | 2.07 | 1.87 | 5.11 | 5.88 | 3.00 | .14 | .63 | .00 | 21.88 |
| 1897-98 | .06 | .00 | .83 | 2.38 | .16 | .70 | 1.96 | .79 | .99 | .31 | 2.15 | .00 | 10.33 |
| 1898-99 | .10 | .00 | .00 | .04 | .22 | .62 | 1.92 | .71 | 1.50 | .08 | .24 | .87 | 6.30 |
| 1899-1900 | .00 | .04 | .05 | .65 | 1.28 | .46 | 1.20 | T. | .78 | 2.03 | 1.41 | .00 | 7.90 |
| 1900-1901 | .04 | .00 | .50 | .53 | 3.88 | .00 | 2.25 | 3.79 | .46 | T. | 1.62 | .04 | 13.11 |
| 1901-2 | .00 | .00 | .00 | .92 | .09 | T. | 1.64 | 2.58 | 2.82 | .36 | .08 | .31 | 8.80 |
| 1902-3 | .07 | .00 | .00 | .06 | 1.40 | 1.50 | 1.16 | 1.41 | 5.86 | 3.88 | .48 | .00 | 15.82 |
| 1903-4 | .00 | .21 | .54 | .06 | .00 | .00 | .29 | 1.50 | 4.55 | .82 | .48 | .00 | 8.45 |

Average, 16 seasons, 13.48 inches.

This very condition of aridity is not without compensating advantages. It is recognized by soil experts everywhere that arid lands are generally fertile. Abundant rainfall leaches the soils of certain valuable soluble fertilizing elements. In the arid regions these soluble elements are retained in the soils, which are correspondingly productive. Aridity also means a large proportion of bright, clear days, and therefore, where water can be artifically applied to the soils, the best of growing conditions. The bench lands about San Bernardino Valley combine these advantages. Their soils are fertile, warm and equable as to temperature, free from alkalinity, and where water has been applied to them have become among the most valuable agricultural lands in the United States. Citrus fruits of the better varieties are cultivated upon them, practically to the exclusion of other crops.

*Rainfall records, San Bernardino, Cal.*

| Year. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May. | June. | Rainfall for season. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1870–71 | 0.00 | 0.00 | 0.02 | 0.09 | 3.11 | 0.89 | 6.91 | 2.21 | 0.19 | 0.34 | 0.11 | 0.07 | 13.94 |
| 1871–72 | .00 | .04 | .13 | .60 | .88 | 3.91 | .00 | 2.20 | .37 | .79 | .06 | .06 | 8.98 |
| 1872–73 | .00 | .18 | .04 | .00 | 1.17 | 4.40 | 6.50 | 1.25 | .51 | .84 | .21 | .00 | 15.10 |
| 1873–74 | .00 | 1.06 | .02 | .01 | .74 | 5.73 | 5.51 | 8.76 | 1.08 | .48 | .42 | .00 | 23.81 |
| 1874–75 | .00 | .00 | .06 | 1.82 | 1.88 | 2.20 | 7.20 | .15 | .22 | .07 | .05 | .00 | 13.65 |
| 1875–76 | .00 | .00 | .00 | .00 | 7.50 | .02 | 6.55 | 1.92 | 3.41 | .44 | .03 | .03 | 19.90 |
| 1876–77 | .00 | .00 | .00 | .20 | .40 | .00 | 3.50 | 4.03 | .83 | .26 | .30 | .00 | 9.52 |
| 1877–78 | .00 | .00 | .00 | .86 | .50 | 3.95 | 3.33 | 6.68 | 2.57 | 1.71 | .66 | .07 | 20.33 |
| 1878–79 | .07 | .00 | .02 | .14 | .05 | 4.70 | 3.59 | 1.00 | .50 | 1.20 | .24 | .03 | 11.54 |
| 1879–80 | .11 | .02 | .01 | .94 | 3.40 | 6.50 | 1.56 | 1.33 | 1.45 | 5.00 | .04 | .00 | 20.[illegible] |
| 1880–81 | .00 | .00 | .00 | .14 | .67 | 8.80 | 1.40 | .36 | 1.66 | .46 | .01 | .00 | 13.50 |
| 1881–82 | .00 | .00 | .00 | .80 | .27 | .50 | 1.11 | 2.65 | 3.30 | 2.91 | .00 | .00 | 11.54 |
| 1882–83 | .00 | .00 | .00 | .10 | .15 | .45 | 1.60 | 1.10 | 2.82 | 2.95 | .00 | .00 | 9.17 |
| 1883–84 | .19 | .00 | .53 | .85 | .09 | 2.63 | 1.63 | 12.20 | 9.95 | 5.68 | 3.17 | .59 | 37.51 |
| 1884–85 | .00 | .00 | .00 | .00 | .11 | 3.75 | 2.79 | .11 | .28 | 1.89 | 1.69 | .19 | 10.81 |
| 1885–86 | .00 | .00 | .00 | .39 | 4.36 | 1.20 | 6.34 | 2.52 | 4.18 | 2.36 | .32 | .16 | 22.8[illegible] |
| 1886–87 | .00 | .00 | .00 | .00 | .11 | .61 | .39 | 6.44 | 4.41 | 1.90 | .42 | .22 | 14.50 |
| 1887–88 | .11 | .04 | .09 | 1.17 | 2.29 | 1.91 | 4.01 | 3.60 | 3.41 | .58 | .52 | .03 | 17.76 |
| 1888–89 | .00 | .00 | .00 | .05 | 4.12 | 4.64 | .93 | 1.50 | 6.55 | 2.05 | 1.13 | .00 | 20.97 |
| 1889–90 | .17 | .63 | .11 | 2.30 | 2.23 | 10.85 | 5.44 | 2.52 | .89 | .00 | .31 | .00 | 25.45 |
| 1890–91 | .13 | 2.16 | .88 | .58 | 1.27 | 3.02 | .00 | 7.78 | .06 | .53 | 1.67 | .00 | 18.[illegible] |
| 1891–92 | .00 | .91 | .93 | T. | T. | 1.67 | 3.24 | 3.30 | 1.75 | .37 | 2.10 | .08 | 14.3[illegible] |
| 1892–93 | .00 | .00 | .00 | .16 | 1.02 | 2.23 | 4.53 | 3.37 | 8.00 | .48 | .03 | .00 | 19.[illegible] |
| 1893–94 | .20 | .00 | .05 | 1.05 | .30 | 2.28 | 1.26 | .88 | 1.15 | .40 | .56 | .00 | [illegible] |
| 1894–95 | .00 | .16 | .37 | .15 | .00 | 7.25 | 7.39 | 1.14 | 3.44 | .64 | .44 | .00 | 20.9[illegible] |
| 1895–96 | .00 | .00 | .00 | .00 | 1.14 | .66 | 2.02 | .00 | 2.92 | .37 | 1.00 | .00 | 8.1[illegible] |
| 1896–97 | T. | .17 | .00 | 2.10 | .98 | 1.09 | 3.40 | 5.40 | 3.41 | .08 | .11 | .00 | 16.74 |
| 1897–98 | T. | .00 | .13 | 2.10 | .21 | .57 | 2.10 | .60 | .97 | .48 | 1.08 | .00 | 8.24 |
| 1898–99 | .00 | .00 | .00 | .03 | .05 | .44 | 2.03 | .51 | 3.22 | .07 | .19 | .95 | 7.[illegible] |
| 1899–1900 | .00 | T. | .01 | .81 | 1.47 | .84 | .92 | .00 | .92 | 1.96 | 1.71 | .00 | [illegible] |
| 1900–1901 | .34 | .00 | .23 | .36 | 6.10 | .00 | 3.48 | 4.58 | .43 | .56 | 1.23 | .05 | 17.[illegible] |
| 1901–2 | .00 | .27 | .07 | 1.09 | .28 | .04 | 1.65 | 3.02 | 3.89 | .57 | .12 | .15 | 11.15 |
| 1902–3 | .01 | .00 | .00 | .09 | 1.94 | 1.94 | 1.96 | 1.67 | 6.47 | 3.10 | .24 | .00 | 17.42 |
| 1903–4 | .00 | .15 | .46 | .07 | .00 | .00 | .18 | 2.21 | 5.34 | .80 | .16 | .00 | 9.37 |

Average, 34 years, 15.06 inches.

The average seasonal rainfall at San Bernardino for thirty-four years is 15.06 inches. It is estimated by meteorologists[a] that a record which has been kept for thirty-five years gives an average that is within 2 per cent of the correct final average, so that for practical purposes it may be assumed that this San Bernardino average is final. It is interesting to note that the average for the last eleven seasons, beginning with that of 1893–94, has been but 12.15 inches, nearly 20 per cent less than the general average, while for the ten preceding seasons the average was 20.11 inches, or more than 33⅓ per cent above the general average. The fact that the last decade has been one of

[a] Binnie, Alexander R., The mean or average rainfall and the fluctuations to which it is subject: Proc. Inst. Civ. Eng., vol. 109, 1892, pp. 89–172.

ow rainfall is very generally recognized, but it is not by any means o clearly understood that the preceding decade, with which the last

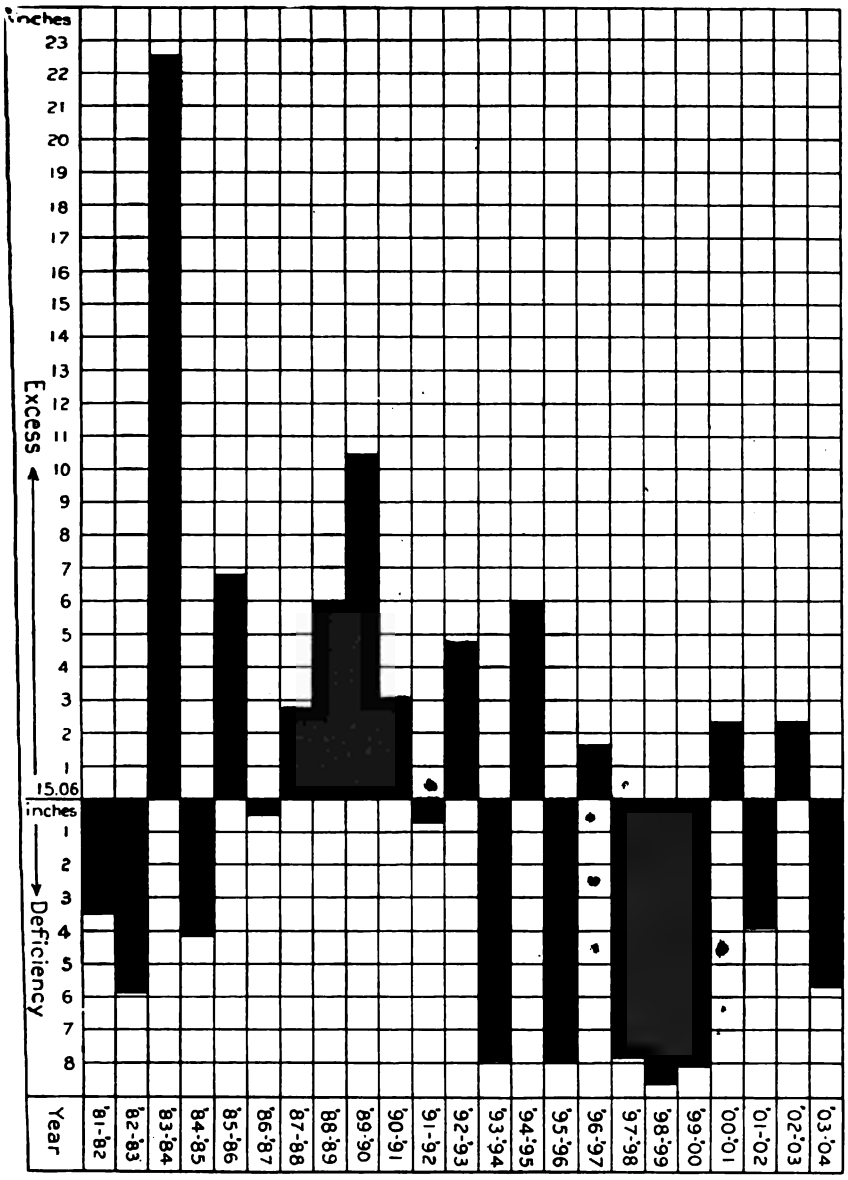



Fig. 1.—Chart showing variation from average rainfall at San Bernardino, Cal. *a*, Average for 34 years (15.06 inches).

is usually compared, was one of great excess. This decade includes the phenomenal season of 1883–84, with a precipitation of 37.5 inches,

12 inches more than that of any other season in the thirty-four years, and probably much the wettest winter in a half century. The driest season in the record is that of 1898–99, with a rainfall of 7.49 inches, only half of the average, and the driest group of three years is that ending with the winter of 1899–1900, with an average of 8.12 inches.

It is also perhaps not clearly understood that in countries of low rainfall there will be more seasons below the average than above it. The less the average rainfall the greater this preponderance of dry seasons. With an average of 15 inches, as at San Bernardino, the preponderance is not great, there having been eighteen seasons below and sixteen above during the last thirty-four years. At San Diego, with an average of about 9.5 inches, there have been twenty-nine seasons below this average and twenty-five above it during the last fifty-four winters. This condition arises from the fact that where the rainfall is low the occasional very wet winter gives an excess of precipitation equal to or even more than the whole amount of the average, while there are no seasons with an equally great deficiency; hence more than one winter of minimum rainfall is required to balance a winter of maximum. To illustrate, during the season of 1883–84 37.51 inches fell at San Bernardino. The lowest rainfall of which we have record is that of the winter of 1898–99, with a precipitation of 7.49 inches. The first was 22.45 inches above the average, the other but 7.57 inches below, so that nearly three years of this minimum would have to be combined with one of the maximum to give the average. There can not be a deficiency of more than 15.06 inches, while there is no limit mathematically to the excess.

## SOILS.

The soils of the upper part of the valley of southern California may, for convenience of discussion, be classed as indigenous and introduced. By the former are meant those which are due to the decay of the underlying or immediately adjacent rock masses; by the latter, those which have been brought by stream action from some distant source.

In the ultimate analysis nearly all valley soils belong to the latter class, since rocks of sedimentary origin themselves represent material which was transported at an earlier time from some more or less distant point. But for our purpose the origin will not be traced so far back. If the soil is derived from an underlying or adjacent rock mass it is classed as indigenous, whether that mass is a late sediment or not.

The soils of the valley bottoms belong in all cases to the derived type. They are the immediate products of the erosional activity of

REDLANDS AND SAN BERNARDINO AND SAN GORGONIO PEAKS.

the streams, which with the uplifting of the mountain masses began the work of canyon cutting, depositing the material which they removed in this process over the lowlands beyond the canyon mouth.

The gravels and soil, then, in the alluvial fan built about the mouth of any canyon, represent only the rocks that are found within the drainage basin of the stream which flows from it. In the lower area about the junction of two fans the rock types of each are mingled, and well out near the center of the valley, where the various tributaries join, there will be a type due to a mixture of all the contributing varieties.

The soil-producing materials yielded by the canyon of the Santa Ana are largely derived from the dioritic rocks which outcrop almost exclusively in its basin. Mill Creek, in addition to dioritic and schistose rocks, yields a noticeable percentage of sandstone. Farther west schistose and gneissoid elements are contributed by Plunge Creek, City Creek, and East and West Twin creeks, while from the lower part of Devil and Badger canyons there is a considerable addition of limestone and marble.

Lytle Creek, which, because of its relatively large and constant flow, has built out a big alluvial fan at the south base of the San Antonio Mountains, flows throughout its course through schistose rocks, and bowlders of these are numerous in its wash.

San Timoteo Canyon is cut in gravels and clays from Beaumont down to Redlands Junction. It has carried into the lower valley comparatively little material, and that little is fine in comparison with the débris of the great fans in front of the mountain canyons, although it contains bowlders and gravels derived from the older gravel beds which outcrop on either side of the canyon.

This alluvial material, which forms the greater part of the floor of the present valley, is very coarse and absolutely untillable about the mouths of the large canyons, where the lands are in the original desert condition. The vineyards about Grapeland are planted on the rather coarse upper slopes of the Lytle Creek fan, while the Rialto citrus groves are on a lower, finer portion of the same feature. The low bench which lies north of Redlands and extends west from Mentone nearly to Colton is of coarse gravel near its upper portion; fine gravel and sand, on which excellent crops of grapes are produced, midway; and sandy clay and loam farther down, in the vicinity of Idlewild. One group of low sand dunes has formed north and west of Slover Mountain. These generally are untilled, although, since they are low and no longer in motion, it is probable that they could be successfully cultivated if sufficient water were available.

Clays which are often sandy lie in the central part of the valley in the artesian belt, where they are sometimes mixed with vegetable

mold. They represent the lowest and finest phase of the alluvial-fan deposits laid down just back of the dam formed by the Bunker Hill ridge.

Thus it is seen that the introduced soils exhibit great variety in texture and a less marked variation in composition, the latter variant depending upon the origin of the material in one or the other portions of the surrounding mountains and the later admixture of vegetable matter, while the former depends largely upon the distance of the soil particles from their source.

The mesa soils exhibit somewhat less marked differences. Over the high lands south and east of Riverside they are derived largely from the underlying and adjacent diorites, so that here they have many of the characteristics of a granitic sand. Generally they are coarser along the easterly higher parts of this mesa and finer in the lower parts nearer Arlington. Since that part of the mesa which lies north of Terquisquito Arroyo and extends through the east Riverside district to the bluff above Santa Ana River is built up of gravels and alluvium, instead of being floored by the massive diorites of the region farther south, the soil is freer from grit than in the latter locality, being, indeed, a rich loam over much of the area.

The soil of the Redlands bench, including Smiley Heights, Redlands Heights, and the slope south of Crafton, is a clay or loam, sometimes gravelly, derived from the weathering of an old alluvium, which, except in its distribution and probable extent, is not unlike that which the rivers are depositing in the great débris cones to-day. Its material is somewhat finer, clay predominates to a greater degree, and the old weathered red surfaces testify to slower deposition, or perhaps to longer exposure to atmospheric agencies before deposition.

The Highlands and East Highlands benches and that lying between the Mill Creek and Santa Ana canyons furnish similar soils derived from the old alluvial-fan material. That, like the modern alluvium, is somewhat coarser next to the mountains and near the mouths of the greater canyons. But even where coarse it contains a notable admixture of clay, which furnishes a basis for a fertile soil.

The most absorptive soils extensively cultivated are probably the sands of the low river terraces north and northeast of Redlands, and perhaps those least absorptive are the clays of the bottom lands about San Bernardino. Absorptive capacity depends, among other things, upon the coarseness of the soil particles, or, as it has been well expressed, upon the "effective size of grain." Hence the clay and loam soils, whether upon the mesa lands or in the bottoms, require much less water for irrigation than the more open sands and gravelly soils. Another element which is of the utmost importance in determining the amount of water that must be applied in order to mature crops is the character of the subsoil. If this is coarse and open,

readily draining the water from the cultivated surface, the waters brought for irrigation may quickly pass down out of reach of the plant roots. On the other hand, a compact and impervious hardpan holds the waters until they are absorbed by the plants. If bed rock lies just under the soil it may serve the same purpose. An excellent example of the effect of this latter relation is to be found near the eastern end of the Jurupa Mountains. The road from Bloomington to West Riverside runs through a wide valley separating an eastern outlier of this group from the main mass. The soils within this valley are a result of the decay in place of the diorites and schists of the hills. They are not of great depth and the massive and almost impervious rock is just beneath them. A small apricot orchard has been planted in the north end of this pass, about 2½ miles southwest of Bloomington, and although not irrigated it is in a flourishing condition and yields abundant crops. The orchard is young and has been in bearing practically only during the years of light rainfall, which began with the winter of 1897–98. The explanation, it is believed, is to be sought in the fact that the impervious bed rock at this point is so near the surface. The water which accumulates through winter rainfall seeps very slowly over this gently sloping floor, and the slight spring and summer seepage from the surrounding hills and slopes is also held here within reach of the plant roots until the crop is matured. In less favorable localities apricots require irrigation, or without it are uncertain in yield.

## WATER SUPPLY.

The ultimate source of all the water to be found in San Bernardino Valley is the rainfall within the drainage basins tributary to it. This statement needs to be clearly made at the beginning of any discussion, because it is constantly stated that some remote point, like Colorado River, or even the Pacific Ocean, may, by a process never clearly explained, supply the bountiful waters found in the San Bernardino cienaga. Aside from the inherent impossibility of such waters rising above their sources, or being filtered free of salt in the case of the Pacific, it is to be remembered that the intervening hills and mountains are much more effective and impenetrable dams than any built by man. The fissures within them are not extensive, and the great faults which mark the more important passes through them are so sealed by the pressures that accompanied their formation as to be nearly, if not quite, as impervious as the unbroken rock.

### EFFECT OF FORESTS.

The precipitation which is the source of all the water falls almost exclusively in the winter months, from November to April, inclusive.

Practically all of that which falls upon the flat and porous valley lands is absorbed immediately or returns to the air at once by evaporation. Of the greater amount which falls upon the mountain slopes, a large proportion is absorbed by the soil and humus where vegetation has not been destroyed by fire and the unprotected soil swept from the bare rocks by succeeding storms. This moisture, taken up by the vegetable mold, the soil, and the rock débris, is released slowly during the succeeding months and is the source of the important summer flow of the mountain streams. The denser the vegetable growth and the thicker the soil cover on the mountain slopes the more effective this direct storage of the winter rains and the more uniform the stream flow during the summer months. These facts are brought out by some measurements made for the Bureau of Forestry in the San Bernardino Mountains in 1899 and published in a paper by J. W. Toumey, entitled "The Relation of Forests to Stream Flow." The following extract contains the essence of the paper:

In a careful study of the behavior of the stream flow on several small catchment areas in the San Bernardino Mountains it has been found that the effect of the forest in decreasing surface flow on small catchment basins is enormous, as shown in the following tables, where three well-timbered areas are compared with a nontimbered one:

*Precipitation and run-off during December, 1899.*

| Condition as to cover. | Area of catchment basin. | Precipitation. | Run-off per square mile. | Run-off in percentage of precipitation. |
|---|---|---|---|---|
| | *Sq. miles.* | *Inches.* | *Acre-feet.* | *Per cent.* |
| Forested | 0.70 | 19+ | 36− | 3 |
| Do | 1.05 | 19+ | 73+ | 6 |
| Do | 1.47 | 19+ | 70− | 6 |
| Nonforested | .53 | 13− | 312+ | 40 |

At the beginning of this rainy season, in early December, the soil on all four of these basins was very dry as a result of the long dry season. The accumulation of litter, duff, humus, and soil on the forest-covered catchment areas absorbed 95 per cent of the unusually large precipitation. On the nonforested area only 60 per cent of the precipitation was absorbed, although the rainfall was much less.

*Rainfall and run-off during January, February, and March, 1900.*

| Condition as to cover. | Area of catchment basin. | Precipitation. | Run-off per square mile. | Run-off in percentage of precipitation. |
|---|---|---|---|---|
| | *Sq. miles.* | *Inches.* | *Acre-feet.* | *Per cent.* |
| Forested | 0.70 | 24 | 452+ | 35 |
| Do | 1.05 | 24 | 428+ | 33 |
| Do | 1.47 | 24 | 557+ | 43 |
| Nonforested | .53 | 16 | 828+ | 95 |

The most striking feature of this table, as compared with the previous one, is the uniformly large run-off as compared with the rainfall. This clearly shows the enormous amount of water taken up by a dry soil, either forested or nonforested, as compared with one already nearly filled to saturation. During the three months here noted on the forested basins about three-eighths of the rainfall appeared in the run-off, while on the nonforested area nineteen-twentieths appeared in the run-off.

*Rapidity of decrease in run-off after the close of the rainy season.*

| Condition as to cover. | Area of catchment basin. | Precipitation. | April run-off per square mile. | May run-off per square mile. | June run-off per square mile. |
|---|---|---|---|---|---|
| | *Sq. miles.* | *Inches.* | *Acre-feet.* | *Acre-feet.* | *Acre-feet.* |
| Forested | 0.70 | 1.6 | 153— | 66— | 25— |
| Do | 1.05 | 1.6 | 146— | 70— | 30— |
| Do | 1.47 | 1.6 | 166+ | 74— | 30+ |
| Nonforested | .53 | 1 | 56+ | 2— | 0 |

The above table clearly shows the importance of forest in sustaining the flow of mountain streams. The three forested catchment areas, which during December experienced a run-off of but 5 per cent of the heavy precipitation for that month and which during January, February, and March of the following year had a run-off of approximately 37 per cent of the total precipitation, experienced a well-sustained stream flow three months after the close of the rainy season. The nonforested catchment areas, which during December experienced a run-off of 40 per cent of the rainfall and which during the three following months had a run-off of 95 per cent of the precipitation, experienced a run-off in April (per square mile) of less than one-third of that from the forested catchment areas, and in June the flow from the nonforested area had ceased altogether.

In view of these facts, which illustrate conditions of wide application, no policy can be conceived which would be more suicidal than one which would permit the stripping of forests or the destruction of these or the chaparral by fires. The immediate and direct result would be the washing away of the earth and humus by the first winter rains, and thereafter destructive floods in winter and dry stream beds in summer. The opposite policy—that of preserving and extending the forest and brush cover—may be expected to tend slowly, and almost imperceptibly perhaps, but none the less surely, toward an equalization of the summer and winter flow of the mountain streams. No public work is deserving of fuller support and more hearty cooperation on the part of the citizens of southern California than this of conservation of the existing plant growth and of forest extension. It is one of the curious anomalies of human nature, but one to which Department workers are well used, that those who have had the work of forest preservation in hand have often had to meet bitter opposition from the very citizens whose vital interests they were at the time protecting.

Before the advent of man in San Bernardino Valley all the waters of the mountain streams, except during periods of exceptional flood, promptly sank when they reached the coarse débris cones at the

mouths of their canyons and continued their journey seaward through the porous sands and gravels with which the valleys are filled. They rose to the surface again only when in their underground passage they reached some impervious obstacle like the Bunker Hill dike above Colton, or the bed-rock obstructions at Riverside Narrows and in the lower canyon of the Santa Ana.

The developments of the last fifty years, however, and especially of the last thirty, have resulted in the appropriation of practically all of the normal flow of these streams for purposes of irrigation. Much the greater part of this diverted stream water is returned to the land within the valley in the process of irrigation, but when thus used and spread out over a large acreage of relatively fine soil a very much larger proportion evaporates directly than when the water entered the coarse gravels at the mouths of canyons previous to its diversion; and another important percentage is absorbed by the growing plants and is transpired through them into the air.

### RETURN WATERS.

The percentage of irrigation water which returns to the underground reservoirs must vary greatly in different localities and with varying soils and irrigation customs. The sandy soils of some of the bottom lands are so loose that the water percolates rapidly through them and much of it is beyond the reach of the plant roots before it can be absorbed. In the finer loam and clay soils, especially those underlain by an impervious hardpan which checks the escape downward of irrigation water, probably but a small percentage avoids evaporation and absorption and so returns to the ground water. This will be especially true where the better irrigation methods are practiced and no more water is put upon the soil than is needed.

In view of these variable and uncertain elements which enter into the problem, it becomes impossible to estimate with accuracy the proportion of diverted stream water which again becomes available for use as return water from irrigation. It can only be said that the percentage must vary within wide limits, perhaps such wide limits as 5 and 50 per cent, and that with improvements in irrigation practice it will become constantly less. Nevertheless, in certain favorable situations, it seems to be of considerable importance, and may result in changing an arid section to one with an abundant or even a superabundant supply. Thus, in the western and lower part of the Riverside colony, within a restricted area, ground waters have increased during years past until bogs have formed and drainage ditches have become necessary. Fifty second-feet of water are constantly applied in irrigation to the higher lands which drain in this direction, and in the past, and to a less marked extent at present, there has been overirrigation in a part of the area.

Santa Ana River, between the intake of the lower Riverside canal and the Auburndale Bridge, has been increasing in volume since measurements were first made in 1888. The following table indicates the extent of the increase between Riverside Narrows and the Auburndale Bridge, but as practically all of the water flowing at the first point rises below the intake of the lower Riverside canal, the difference between the earlier and the later measurements there is also to be regarded as due to an increase in the volume of rising ground waters.

*Discharge measurements of Santa Ana River.*

| Date. | Point of measurement. | Discharge. | |
|---|---|---|---|
| | | *Miner's inches.* | *Second-feet.* |
| 1888. | | | |
| July 16 | Jurupa or Riverside Narrows | 505.0 | 10.10 |
| July 17 | do | 525.0 | 10.50 |
| July 17 | Auburndale Bridge | 728.5 | 14.57 |
| August 21 | Jurupa or Riverside Narrows | 425.5 | 8.51 |
| August 22 | Auburndale Bridge | 664.5 | 13.29 |
| September 14 | Jurupa or Riverside Narrows | 474.0 | 9.48 |
| September 15 | Auburndale Bridge | 709.5 | 14.19 |
| 1889. | | | |
| August 13 | Jurupa or Riverside Narrows | 550.0 | 11.00 |
| August 14 | Auburndale Bridge | 777.5 | 15.55 |
| September 27 | Jurupa or Riverside Narrows | 560.0 | 11.20 |
| September 28 | Auburndale Bridge | 832.5 | 16.65 |
| 1890. | | | |
| August 12 | Jurupa or Riverside Narrows | 937.9 | 18.76 |
| August 13 | Auburndale Bridge | 1,112.5 | 22.25 |
| 1891. | | | |
| September 9 | Jurupa or Riverside Narrows | 775.0 | 15.50 |
| September 10 | Auburndale Bridge | 1,281.5 | 25.63 |
| 1892. | | | |
| September 10 | Jurupa or Riverside Narrows | 1,469.1 | 29.38 |
| September 11 | Auburndale Bridge | 2,171.4 | 43.43 |
| 1899. | | | |
| September 9 | Jurupa or Riverside Narrows | 1,984.5 | 39.69 |
| September 12 | Auburndale Bridge | 2,991.5 | 59.83 |
| 1900. | | | |
| July 27 | Jurupa or Riverside Narrows | 1,920.5 | 38.41 |
| July 28 | Auburndale Bridge | 2,722.0 | 54.45 |
| 1901. | | | |
| August 30 | Jurupa or Riverside Narrows | 1,693.5 | 33.87 |
| August 27 | Auburndale Bridge | 2,185.0 | 43.70 |

[illegible]

[illegible]

| [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |

[illegible]

[illegible] usually attributed to return [illegible] Pomona, [illegible] that the greater part of it is correct[illegible] [illegible] which deserve [illegible] [illegible] in the early [illegible] the mountains in the [illegible] vary widely in rate, [illegible] of the material through which [illegible] feet per day have been [illegible] in the narrows of Los Angeles [illegible] maxima are reported by Professor Slichter [illegible] Pomona and from the Paso de Bartol[illegible] [illegible] a year, is assumed, the [illegible] during the last sixteen years may [illegible] the average of the waters that acc[illegible] near the mountains during the decade of wet [illegible] show these waters would have [illegible] of gravels between the canyon [illegible] the part of the Santa Ana in question. No criteria are [illegible] between these two possibilities [illegible] Santa Ana shrinks again later during a period when [illegible] of the present decade is due to reach it, we can [illegible] are to be attributed to this slow passage [illegible] through the underground pores [illegible] is maintained or continues to [illegible] that it is due to returning irrigation waters

[illegible] in the drainage basin of Los Angeles River: Water-Sup[illegible]

## SAN BERNARDINO ARTESIAN AREA.

About 1870 it was found that a pipe sunk 50 to 100 feet into the earth, anywhere within the area of moist lands now forming the well-known San Bernardino artesian basin, would yield flowing water. During the succeeding decade many wells of small bore were sunk, chiefly for domestic purposes, and in some instances the water was piped through dwellings, the artesian pressure being quite ample in many cases to force it wherever needed in the houses.

The rapid development of the valley during the decade from 1880 to 1890, coupled with the fact that practically all surface waters had been appropriated by that time, led to an extensive use of the underground waters of the artesian belt as a source of water supply. During the later eighties and the early nineties the great majority of the wells of the Gage canal system were put down, and the Riverside Water Company considerably augmented its supply from Warm Creek and the Santa Ana by sinking a number of deep wells within the artesian belt. The Lytle Creek cienaga was also developed as a source of domestic water by the cities of San Bernardino and Colton, and for irrigation water by a number of irrigation districts.

The seemingly unlimited amount available in the great cienaga, and the resistance which it had offered previous to 1897 to the drains upon it during the preceding decade of rapid development, led to great confidence in it and gave many the impression that as a source of water it was independent of seasonal variations in precipitation, of diversions of streams tributary to the valley, or of drafts upon its stored supply. The concurrence of the series of years of low rainfall, beginning with the winter of 1897–98, with the gradually increased use of waters developed during the preceding decade, soon produced its effect, however, and for some years the artesian area has been shrinking, the flow of wells within it diminishing, and the water plane without it rapidly falling. An increase of rainfall at once affects water levels, as is shown by the seasonal increase of flow from artesian wells during the winter and the particularly noticeable rise in water levels after the winters of 1900–1901 and 1902–3. In most cases, however, these improvements in conditions do not last through the succeeding dry season because of the heavy drafts now being made upon the basin. The general reduction in flow and lowering of the water plane, although most clearly recognized during the dry years succeeding 1896–97, had been noticeable earlier. A few artesian wells are reported to have ceased flowing as early as 1890 or 1891, and a number about the borders of the basin had ceased before 1896.

Before considering further the drafts upon the artesian supply and their probable ultimate effect it is necessary to discuss the origin, outlines, and underground conditions of the artesian basin, since its

*Discharge measurements of Santa Ana River*—Continued.

| Date. | Point of measurement. | Discharge. | |
|---|---|---|---|
| | | *Miner's inches.* | *Second-feet.* |
| 1902. | | | |
| October 10 | Jurupa or Riverside Narrows | 2,162.5 | 43.25 |
| September 2 | Rincon Bridge [a] | 3,750.0 | 74.90 |
| 1903. | | | |
| August 25 | Jurupa or Riverside Narrows | 2,035.0 | 40.70 |
| August 19 | Rincon Bridge [a] | 3,000.0 | 60.00 |

[a] Measurements are now made at Rincon wagon bridge, instead of at Auburndale Bridge as formerly. Measurements made at these two points, by W. B. Clapp, on September 23, 1903, indicate that the flow at the former point is about one-third more than at the latter.

This rather remarkable increase is usually attributed to return waters from irrigation in the vicinity of Riverside, Pomona, and Ontario, and it is probable that the greater part of it is correctly assigned to this cause, but there is another possibility which deserves to be considered. The decade of excessive rainfall ending in the early nineties thoroughly saturated the gravels near the mountains in this part of the State. Subsurface percolation varies widely in rate, this being dependent upon the coarseness of the material through which the water passes. Rates between zero and 96 feet per day have been measured by Mr. Homer Hamlin[a] in the narrows of Los Angeles River, and rates with lower maxima are reported by Professor Slichter from Mohave River below Victorville and from the Paso de Bartolo. If a rate of 25 feet a day, or less than 2 miles a year, is assumed, the increasing flow of Santa Ana River during the last sixteen years may be due in part to the slow escape to the river of the waters that accumulated in the alluvium near the mountains during the decade of wet years preceding the present dry epoch, since these waters would have to pass through from 10 to 20 miles of gravels between the canyon mouths and the part of the Santa Ana in question. No criteria are known by which we can distinguish between these two possibilities at present. If the Santa Ana shrinks again later during a period when the minimum rainfall of the present decade is due to reach it, we can conclude that its fluctuations are to be attributed to this slow passage of the waters of wet and dry periods through the underground pores. If, on the other hand, its increased flow is maintained or continues to increase, this will prove that it is due to returning irrigation waters.

[a] Hamlin, Homer, Underflow tests in the drainage basin of Los Angeles River: Water-Sup. and Irr. Paper No. 112, 1905, pp. 34–50.

## SAN BERNARDINO ARTESIAN AREA.

About 1870 it was found that a pipe sunk 50 to 100 feet into the earth, anywhere within the area of moist lands now forming the well-known San Bernardino artesian basin, would yield flowing water. During the succeeding decade many wells of small bore were sunk, chiefly for domestic purposes, and in some instances the water was piped through dwellings, the artesian pressure being quite ample in many cases to force it wherever needed in the houses.

The rapid development of the valley during the decade from 1880 to 1890, coupled with the fact that practically all surface waters had been appropriated by that time, led to an extensive use of the underground waters of the artesian belt as a source of water supply. During the later eighties and the early nineties the great majority of the wells of the Gage canal system were put down, and the Riverside Water Company considerably augmented its supply from Warm Creek and the Santa Ana by sinking a number of deep wells within the artesian belt. The Lytle Creek cienaga was also developed as a source of domestic water by the cities of San Bernardino and Colton, and for irrigation water by a number of irrigation districts.

The seemingly unlimited amount available in the great cienaga, and the resistance which it had offered previous to 1897 to the drains upon it during the preceding decade of rapid development, led to great confidence in it and gave many the impression that as a source of water it was independent of seasonal variations in precipitation, of diversions of streams tributary to the valley, or of drafts upon its stored supply. The concurrence of the series of years of low rainfall, beginning with the winter of 1897–98, with the gradually increased use of waters developed during the preceding decade, soon produced its effect, however, and for some years the artesian area has been shrinking, the flow of wells within it diminishing, and the water plane without it rapidly falling. An increase of rainfall at once affects water levels, as is shown by the seasonal increase of flow from artesian wells during the winter and the particularly noticeable rise in water levels after the winters of 1900–1901 and 1902–3. In most cases, however, these improvements in conditions do not last through the succeeding dry season because of the heavy drafts now being made upon the basin. The general reduction in flow and lowering of the water plane, although most clearly recognized during the dry years succeeding 1896–97, had been noticeable earlier. A few artesian wells are reported to have ceased flowing as early as 1890 or 1891, and a number about the borders of the basin had ceased before 1896.

Before considering further the drafts upon the artesian supply and their probable ultimate effect it is necessary to discuss the origin, outlines, and underground conditions of the artesian basin, since its

capacity as a storage reservoir, the rapidity with which its supply may be renewed, and the rate at which this supply may be drawn upon depend upon these underground conditions.

### ORIGIN OF SAN BERNARDINO BASIN.

A great fault runs northwest and southeast through Cajon and San Gorgonio passes and along the base of the San Bernardino Mountains. In the movement along this fracture a portion of the earth's crust north of the present valley was uplifted and now forms the San Bernardino Mountains, while the valley itself represents a great depressed area south of the fracture.

Another crustal movement, whose beginning at least may well have been contemporaneous with the first, both being very late geologically, resulted in the lifting of a ridge—the formation of an irregular arched wrinkle—extending from the San Jacinto Mountains northwestward along the line of the Badlands, which separate San Timoteo Canyon from San Jacinto Valley. The rocks which were folded into this arch are soft shales and sandstones and gravelly alluvium, like that deposited by the rivers now in San Bernardino Valley. This fold can be traced on the surface as the Bunker Hill dike to a point nearly 2 miles somewhat south of west of San Bernardino. It probably extends even farther in the direction of Lytle Creek Canyon as an underground feature, buried beneath the modern wash, but there is no surface indication of its presence there.

This clay and gravel ridge has been the most effectual of subsurface dams, against which the modern stream wash has accumulated, and behind which the waters percolating seaward through this wash have been stored, the excess rising in springs and flowing over the dam, to sink again in the sands and gravels below.

It is not possible to determine in detail the character of the floor of the San Bernardino basin, but we can gain a conception which is probably correct in its general outlines by a consideration of the nature of the surface whose deformation gave rise to it.

Before the San Bernardino Mountains were uplifted and San Bernardino Valley was formed subaerial erosion had reduced an earlier topography to a condition in which the valleys were wide and generally level and the mountains low, although often steep, because the granitic rocks from which they were carved weather characteristically into steep forms.

Such a surface is now to be found in the triangle at whose vertices are Riverside, Elsinore, and San Jacinto. Other fragments of this old landscape are, it is believed, still preserved in practically the condition in which they existed previous to the deformation in Bear Valley and its continuation about Baldwin Lake (Pl. II, *B*), in Holcomb Valley, in Little Bear Valley, and in other of the areas

now forming some of the higher parts of the San Bernardino Mountains.

The topography of these higher areas, where it has not been altered by modern gorge-producing agencies, consists of broad valleys with ridges of moderate elevation between them and is much like that in the region north of Elsinore. It is believed that these two regions, now so widely separated geographically and in elevation, once formed a continuous surface, and that San Bernardino Valley, between them, was a part of this surface, like the other parts in character and developed with them.

### DEPTH OF THE BASIN.

When the series of earth strains which deformed the region came into play, Perris Valley was raised slightly, the San Bernardino Mountains were raised much more, and San Bernardino Valley, between them, sank until parts of its old surface came to occupy a position below sea level. How much below it, it is not possible to tell with any exactness, since the deepest wells bored in the center of the valley do not reach bed rock, and the character of the movement and of the land affected was such that it is difficult to estimate the amount of the displacement. An estimate, which, however, is little more than a guess, may be made by considering the maximum relief preserved upon the old surface and applying the criteria thus obtained to San Bernardino Valley.

The heights about Bear Valley usually do not rise more than 3,000 feet above its level; those surrounding the other flat mountain valleys rarely attain this relief. The Jurupa Mountains stand nearly 3,000 feet higher than bed rock in the neighborhood of Bloomington. The peaks within Perris and San Jacinto valleys are generally less than 2,000 feet above the floors of the surrounding lowlands, where the depth to these is known. On the whole, it seems fair to assume about 3,000 feet as the maximum relief on the old surface.

North of a median line through the San Bernardino basin a range of low bed-rock hills rises through the modern wash. These are believed to be hills inherited, like the Jurupa Mountains, from the predeformation surface. On the supposition that they originally stood at about 3,000 feet above the valley floor, this should now be only 2,000 or 2,500 feet beneath San Bernardino.

By assuming that the average slope of the hills, before their burial under the modern wash, was 1,000 feet to the mile—a supposition which is believed to be sufficiently conservative—and that this slope was continuous from the little bed-rock mound below Del Rosa southwestward to the line of disturbance marked by the Bunker Hill dike—a supposition which seems likely to give a greater depth to bed rock than the true one—we reach the conclusion that the latter lies less than 3,000 feet beneath San Bernardino. Nothing whatever is

known of the details in the buried old topography under the modern gravels. Perhaps bed-rock hills exist there which differ from those that rise above the wash along the northern edge of the valley, only in that they are not so high and have been completely covered by the modern alluvium, or the floor of the middle of the valley, extending northwest and southeast beneath San Bernardino, may be relatively smooth like that of Perris Valley. Whatever its character, the rough estimate of 3,000 feet or less from the present surface to it is the best that can be made with the data at hand. (Fig. 2.)

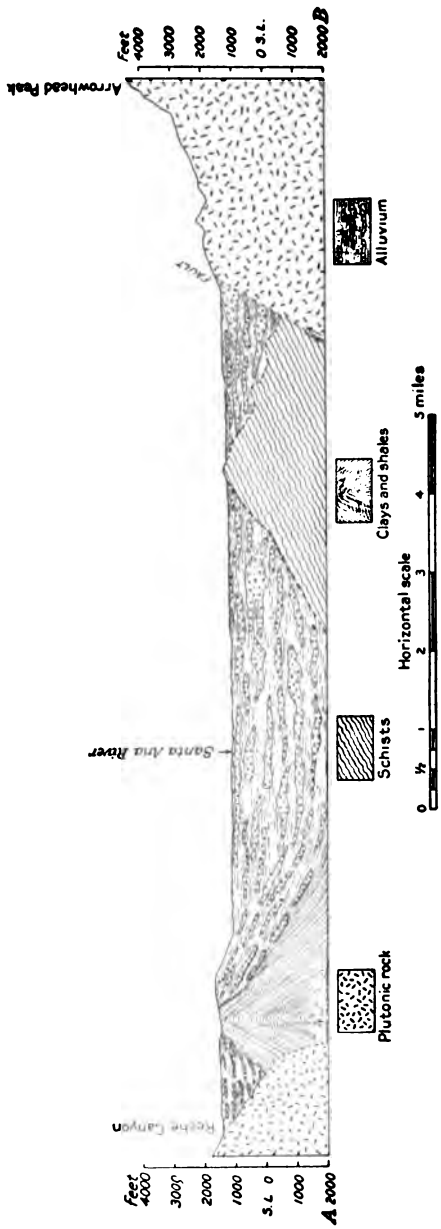



FIG. 2.—Approximate section across San Bernardino Valley along the line A-B, Pl. XII.

GENERAL CLASSES OF ROCKS.

From the point of view of the water supply, the rocks of the upper San Bernardino region may be subdivided into two general classes—those which outcrop everywhere in the higher mountain regions and in many of the hills within the valleys, and the clays and alluvium which fill the valleys, underlie most of the fertile mesas, and form the greater part of the low hills known as the Badlands between San Jacinto and upper Santa Ana valleys. Pl. XII shows the distribution of the water-bearing and non-water-bearing rocks of the region.

The rocks of the first group technically include such widely different varieties as schists, gneisses, diorites, marbles, quartz-porphyries, sandstones, and conglomerates, but they have the common characteristic of relative compactness, and so absorb and store but little water. The sandstones and conglomerates which are included in this class, although belonging to a group of rocks

which in many regions are valuable water bearers, are here so changed by metamorphic processes as to be practically impervious, as is the case with the schistose sandstones of the Jurupa Mountains, or are so broken and so closely folded that their stored water is too small in amount and too doubtful in position to be of value, as is true of the sandstones in the lower part of Mill Creek Canyon, and of those which form a narrow interrupted band along the south foot of the San Bernardino Mountains from East Highlands to Cajon Pass.

The rocks of the second group are the important ones from the point of view of the water user. They consist largely of alluvium, i. e., of sands, gravels, and clays which have been deposited by streams under conditions very similar to those prevailing in San Bernardino Valley to-day, but at their base is a rather widespread series of fine clays and shales, which outcrop along the axis of the Badlands ridge and at various points on the western flanks of the San Jacinto Mountains. These clays carry fresh-water fossils, and their presence indicates that an inland lake whose extent is uncertain existed at least along the southern border of what is now the San Bernardino basin in late Tertiary times, before the earliest of the valuable water-bearing gravels were deposited.

From the fineness of these clays we infer that no very marked relief existed near by at the time of their deposition, because high mountains usually yield coarse detritus, and from the fact that they are bent into sharp folds we know that extensive earth movements have taken place since their deposition. These two facts lead to the belief that the clays are older than the formation of San Bernardino Valley and the San Bernardino Mountains. They were likely deposited in a lake like Bear Lake, but much larger, on the old land surface of rather moderate relief which existed in this part of southern California before the present high mountains came into existence. The topography of that time, it is inferred, was much like that of Perris Valley or of the higher parts of the San Bernardino Mountains at present—that is, there were wide, nearly level valleys, and from these rose ridges or peaks to moderate elevations of a few hundred, or in extreme cases of perhaps a few thousand, feet.

The old lake probably occupied the lowest of the valleys of that time, and within it islands of the granitic or gneissoid bed rock rose, perhaps, as the Box Springs and Lake View mountains now rise above the Perris and San Jacinto plains. It seems probable that these fine deposits extend under at least a part of the San Bernardino cienaga, and that in deep drilling they may be encountered before the granitic bed rock is reached. The beds laid down in the bottom of this lake were too fine to be of value as water bearers, but they furnish a comparatively impervious plane above which the waters accumulate, and

when thrown into a fold across the course of a river, as in the case of the Bunker Hill dike, they force to the surface the waters percolating through the porous gravels above them, or if an impervious clay layer intervenes between the porous stratum and the surface, they dam back the water so that it is held under pressure and flows when the upper bed is pierced by a drill.

Some time after the deposition of the Badlands clays which have been described, a series of crustal movements began, which folded the clays and seems to have elevated the San Bernardino and perhaps other mountain masses until they stood well above the adjacent valleys, but were perhaps 2,500 feet lower than at present. It is probable that at the same time San Bernardino Valley subsided somewhat, so that its rock floor, sheeted over by the lacustrine silts, stood at a lower elevation than before the movement. At any rate, conditions prevailed which were much like those of the present. Mountain streams were active; they cut deep canyons and carried the products of their erosional activity out into the lowlands as they now do. This detritus contained much coarse material, but on the whole was probably not quite so coarse as the fan material of to-day. It was widely distributed over the lowlands south of the mountains—bowlder beds, sand beds, and clays alternating in an uncertain succession until many hundreds of feet of alluvium were piled up.

At the close of this epoch in the geographic development of the region, movement was resumed along the lines followed during the earlier period. This movement lifted the San Bernardino Mountains to their present elevation. It raised the earlier deposited alluvial wash into the sloping mesas of Smiley Heights and Redlands Heights. It probably resulted in the uplift of the Yucaipe bench to a position somewhat higher than that it had occupied before, and the coarse bowlder beds south of San Timoteo Canyon were given the strong northerly dip which they now have. San Bernardino Valley, which had been depressed in the earlier movement and filled by the erosion following, seems to have again subsided. After this readjustment of the relations of valley and plain, stream activity was renewed, erosion became more active than ever, the present deep canyons were cut, the modern fans were built, and the great alluvial filling, which makes the present surface of San Bernardino Valley and serves as such a valuable storage reservoir for irrigation and domestic waters, accumulated.

This, in brief, is the history of the geologic and physiographic processes which have given us the conditions that now exist and have resulted in the deposition of the gravels that serve as porous reservoirs and the clays that act as impervious caps that confine the water under pressure or as equally impervious bottoms to the water basins. Such a sketch completed, we are in a position to discuss intelligently and more minutely the formations which are water bearing, their

*A.* LATER ALLUVIUM EXPOSED ALONG THE EDGE OF EAST RIVERSIDE MESA.

*B.* THE LATER ALLUVIAL FAN ABOUT KENWOOD.

character, distribution, attitudes, and storage capacity, and to draw from the discussion some practical conclusions.

The two important water-bearing formations are, as may readily be inferred from the preceding discussion, the two series of deposits of river wash, which will be spoken of as the earlier and the later alluvium. They are much alike in character, having been deposited under very similar conditions, the differences being that the later alluvium is somewhat coarser than the earlier, has a smaller amount of cement gravel—that is, bowlders embedded in a hard clay, which is often sandy—and has less extensive beds of clay sufficiently pure to be practically impervious to water. Another difference is not in character, but in attitude, the beds of the later alluvium being in just the position in which they were deposited by the rivers that brought their materials from the mountain canyons, while the beds of the earlier alluvium have been disturbed since their deposition—have been given marked dips in one or another direction and have been raised in places until they are now much higher than when deposited. Since water always flows down grade when free, these attitudes are important in their effect upon the circulation of the contained waters.

### ALLUVIAL FANS.

Extensive accumulations of coarse or poorly assorted stream-deposited rock fragments, such as constitute alluvial fan material or glacial débris, always indicate that, for some reason, the process of rock disintegration is more rapid than that of removal. In glaciated regions piles of unsorted rock fragments testify to a rapidly accumulated supply concentrated at certain points. In arid regions the very differently arranged masses of débris bear witness, not necessarily to especially rapid accumulation, but to slow removal, because of a dearth of the universal agent of removal, water. Hence, where other conditions, such as character of rocks, height of mountains, etc., are equal, greater aridity is indicated by steeper fans of greater mass and coarser material.

The accumulations take place in glaciated regions because, although the volume of water, which is the great distributing agent, is large, the material is supplied in such quantities that the rivers can not successfully cope with the problem of its removal. It gathers, therefore, and forms the rubble heaps. In the arid regions the same result is attained because of another condition—the smallness of the water supply and the consequent incapacity of the streams. Disintegration may not take place more rapidly than in humid regions, but removal is much slower, hence the spectacle, not rare in the Mohave Desert, of mountains nearly buried under the material which has resulted from their own slow breaking down. With an accession of rainfall the process of removal is accelerated, and the fans formed earlier are gullied and

gradually worn away. It is thus seen that the extent of the alluvial cone accumulations is, within certain restrictions, a measure of aridity. Their presence means limited rainfall; the greater their extent the less the mean annual precipitation where conditions of topography and of rock masses are similar, and the less their extent the greater the precipitation.

The alluvial cones of San Bernardino Valley (Pl. VIII), therefore, testify to the partial aridity of its climate. As these are small in relation to the mountains about whose bases they are found, when compared to those about the bases of the desert ranges, so the valley rainfall is large as compared to the desert rainfall. Yet the striking general fact remains that the most important subterranean water-storage reservoirs of San Bernardino Valley came into existence partly because of the limited rainfall of that region.

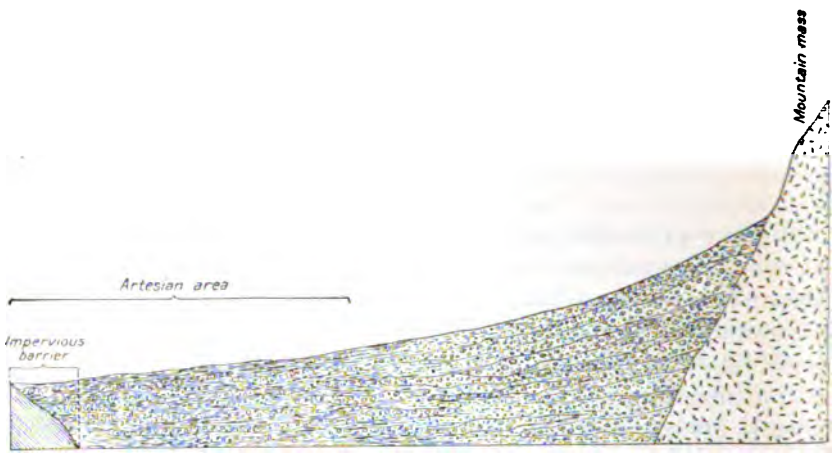



FIG. 3—Diagrammatic longitudinal section of alluvial fan.

The conditions under which this alluvium has accumulated are, in general terms, simple. Variations in temperature, which cause unequal expansion of the different minerals constituting a rock; freezing of the moisture which has entered rock fissures in the higher mountains; slow solution of some minerals by rain waters, thus releasing others; the forcing apart of rock masses by the roots of different forms of vegetation; and the occasional shattering by earthquake shocks, all help to initiate the disintegration of the rocks of the mountain areas. Once a fragment is loosened, gravity or moving water carries it to a lower point. Thus, in the canyons, quantities of rock débris are constantly accumulating. The normal light flow of the summer season removes only the very fine or the soluble matter. The greater part of the work of removal is accomplished during the brief storms, when torrents rush through these constricted defiles, their carrying capacity

increasing at the enormous ratio of the sixth power of their velocity. At such times great bowlders are readily moved and smaller ones are rolled long distances. Gradually they are worked along toward the mouth of the canyon. As soon as the stream reaches the open valley it spreads, loses velocity, and drops its load, the heavier fragments being deposited first and the lighter ones carried farthest. Thus the alluvial cone, coarsest and steepest near the base of the mountain and finer and flatter at a greater distance, gradually accumulates. With a succession of years of heavy storm, trains of bowlders will be carried far down the slope and dropped over the finer deposits which collected during preceding years when the precipitation was light. Or, as one channel is built up in the manner in which a river builds up its bed higher than the surrounding areas, the course of the stream will shift on its fan to a lower channel; earlier-formed deposits will be cut away and fine material will be deposited upon coarse, or coarse upon fine.

Moderate storms may bring heavy material to the mouth of the canyon and there drop it. A succeeding heavier storm will pick up the coarse material laid down in the bed of the stream, move it farther out the slope, cutting into the earlier-deposited burden in the process, and so establishing a new course which will be filled in its turn.

After violent storms, during which turbulent waters highly charged with silt spread far and wide over the sands and gravels of the fans, a film of fine mud is usually found over the river wash; it has been deposited as the muddy flood waters subsided and sank into the sand and gravel. Not all of this fine suspended material was left at the surface, but much must have been carried down by the sinking waters, gradually filtered out from them as they percolated through the porous deposits, and left as a clay cement in the interstices between the sand and gravel grains. Much of that muddy film left at the surface may be later carried down in a similar way by local rains and become a cement for the coarser material. It is believed that in this way originated a part of the "cement gravel" and "cement sand" so often reported by drillers and so well exposed in sections of the first alluvium along the sides of San Timoteo Canyon. It makes a stratum practically as impervious to water as one of pure clay. Others of these cement beds probably represent "hardpans," formed just beneath what was the surface at the time of its formation, but which since has been deeply buried by the growth of the fan.

From this outline of the manner in which the alluvium accumulates it will be seen that it forms an extremely irregular mass of sands, gravels, and clays. Its stratification is very rude, not to be compared in regularity with that in materials deposited by the still waters of lakes and seas, but it is more perfect at a distance from the source of

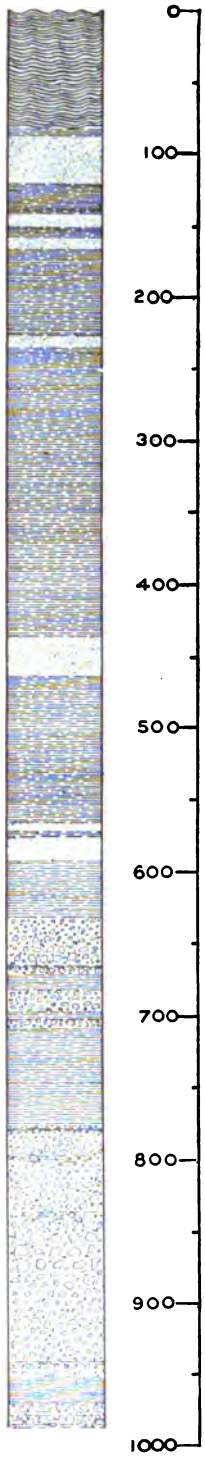


FIG. 4.—Section of the Bucher well.

the material than near it. The general arrangement is radial, the deposits spreading out fanlike from the mouth of the canyon, a particular bed often becoming wider as well as finer at the greater distances, just as the stream itself spreads out over a greater expanse as it reaches the flatter lands some distance from the canyon mouths. Cross-bedding and local unconformities are abundant. Where old river deposits are exposed for examination, as along the bluff forming the north edge of the Riverside-Highlands mesa (Pl. VI, *A*), channels filled with sand and gravel are to be seen cutting across earlier deposits of coarser or finer material, thus forming "pockets" and explaining fully the discordance often observed in the records of adjacent wells (figs. 5, 6, and 9), a water-bearing gravel stratum or a clay bed in one being entirely absent in another near by because in the shifting of channels it has been cut away after deposition.

### WELL RECORDS.

Hundreds of wells have been sunk in the valley of the Santa Ana in the last twenty-five years in the search for water for domestic purposes or for irrigation, and the records of these illustrate abundantly the conditions which have just been described. Excavations in the wash north of Redlands show a mass of roughly stratified sand, gravel, and bowlders, all open, pervious material through which the water can percolate freely. Higher up in the Santa Ana channel the bowlders become large, the fine material becomes smaller in amount and coarser, and the size of the open spaces greater, although the percentage of voids is less, because the space occupied by each large bowlder is free from voids.

Within the limits of the present and the original artesian basin the characteristic feature is the presence of extensive sheets of clay (figs. 4, 5, 6, and 9). They are the finer deposits in this lower part of the fan, as the sands and fine gravels are the finer deposits at higher points. While in some of the well logs along the extreme lower edge of the water-bearing lands clay entirely free from grit is encountered, about the borders it becomes sandy, so that at times the driller is in doubt as to whether it should be classified as a fine sand or as a sandy clay; hence, while we have not continuous sections upon which to base a

judgment, it is highly probable that upstream the clays merge into fine sand, then into coarse sand, and so represent only the marginal phases of the finer fan deposits. Their porosity must likewise gradually increase upstream from the cienaga, so that, whereas they are impervious caps along the lower borders of the basin, they become open and permit seepage, especially under pressure at higher points.

These clay beds are distributed at various horizons between the surface and the bottoms of the deepest wells drilled, whose depth is about 1,000 feet. The fact that they are often sandy, so that one driller will class a bed as fine sand while another calls the same stratum clay, together with the distinctively irregular character of stream deposits, the local unconformities resulting sometimes in the complete cutting out of a bed at one point and its replacement by another usually coarser, makes the correlation of the minor individual beds through the medium of well records a very uncertain undertaking indeed, and one which it is not possible to carry out unless the wells studied are very near together. In a group of wells within a prescribed area, however, it is usually possible to subdivide the strata into broad units which may be recognized in each well.

This is illustrated in the case of the group of wells belonging chiefly to the Gage Canal Company, and lying from 1 to 2 miles northeast of Loma Linda (fig 5). Throughout this group, originally very important as a source of artesian water, and still yielding a limited supply by natural flow, although many pumps are now installed, a cap of clay 50 to 100 feet thick is first pierced by the drill. Beneath this clay cap is a bed of sand and gravel, often coarse, varying from 100 to 200 feet in thickness. This gravel is saturated, and although the water is not now under sufficient head to flow, it is a satisfactory source from which to pump. This same extensive gravel bed is pierced by two deep wells, designated "P" and "O" of the Gage system on the west bank of the canal just north of Colton avenue, and by an important group of shallow wells east of the extension of D street, San Bernardino. These latter wells belong to the Riverside Water Company and to the Riverside Highlands Company, and since their surface elevation is 50 to 100 feet lower than that of the Gage wells above noted, they flow readily, although the head is not great enough to produce a flow in the less advantageously situated Gage wells.

Below this higher, clearly marked gravel series is a zone of interbedded sands, clays, and gravels about 200 feet thick. The occasional gravel streaks of this series contain water under pressure, so that it flows or rises nearly to the surface. Under this is found a second heavy and apparently rather regular gravel mass in which flowing water is obtained. As it lies 500 to 600 feet beneath the surface, it is tapped by only the deeper wells, and has been pierced by but one or two, so that its extent and regularity are problematical.

In a group of wells lying just west of the Victoria tract and north of the Southern Pacific Railroad, from which the city of Riverside gets

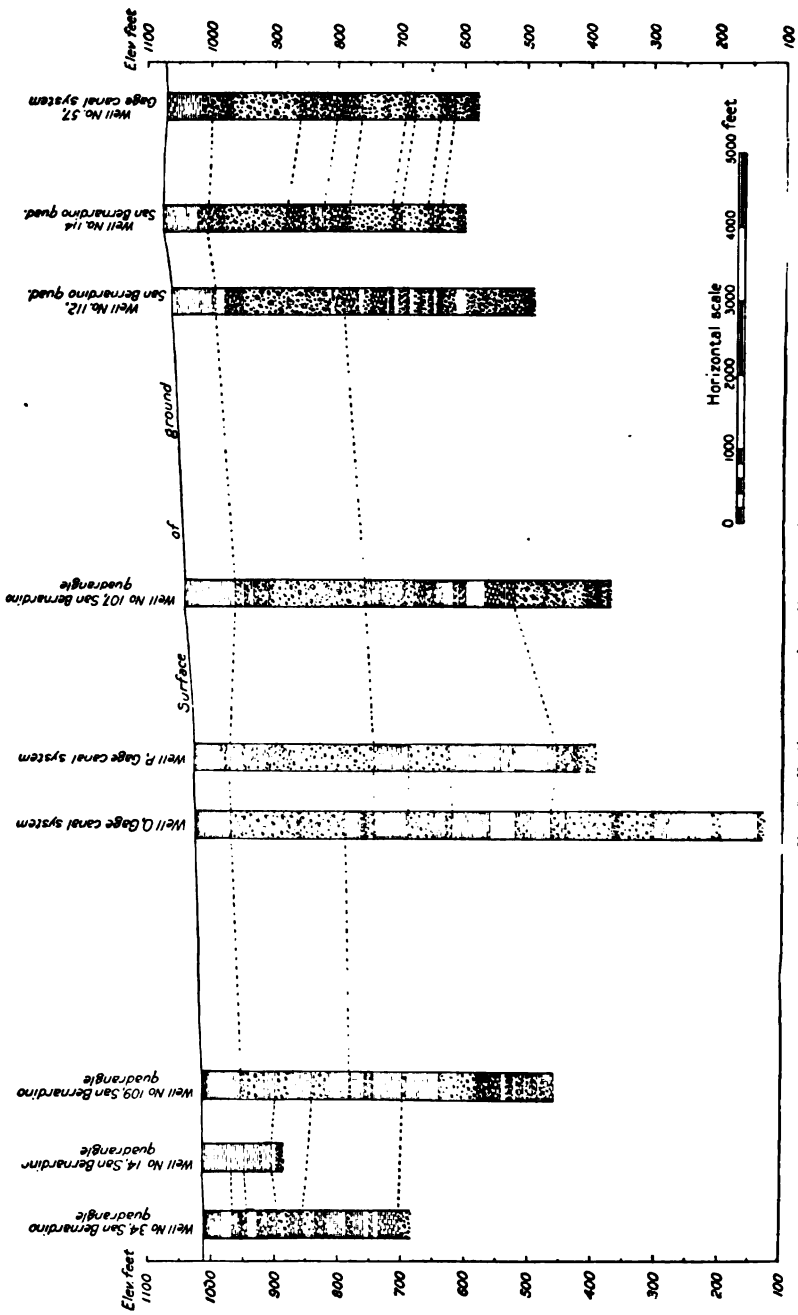



FIG. 5.—Well sections along line A–B, Pl. XII.

its domestic water supply, the upper clay stratum of the Gage wells is recognizable, although sometimes divided into two or more parts by

sandy layers. A bed of coarse water-bearing gravel immediately beneath this occupies the same relative position as the upper heavy bed in the Gage wells, but when penetrated seems to be much thinner. It may be the thin edge of a heavy gravel lens, whose maximum thickness is revealed in the Victoria group. As records are available from only two of these wells which exceed 500 feet in depth, no data exist for an attempt to correlate the deeper strata with those of adjacent groups.

All of the wells which have been considered lie in the lowest part of the San Bernardino cienaga; they therefore exhibit a greater proportion of fine material and a greater regularity in stratification than is to be found in other portions of the basin that lie nearer the mountainous areas and nearer the source of supply of the alluvium.

This is illustrated by a comparison of the records of those wells which lie along Warm Creek from Waterman avenue northeast to Harlem Springs. Many of these wells show a gravel bed immediately beneath the surface soil, although, in the westernmost and deepest, the Waterman avenue well of the Riverside Water Company, the drill passed through 140 feet of clay before entering any extensive gravel body (fig. 6).

Wells but a few hundred feet apart, as, for instance, the first of the new wells drilled by the city of San Bernardino in the Antill tract in 1904, and one of the near-by wells of the Riverside Water Company, exhibit such disparity in the succession of strata that a clay or gravel bed in one can not with any certainty be recognized in the other. The easternmost wells of this group have much less clay than those farther west.

Outside the artesian area, well records show but little of the clay element. A number of records have been examined from the vicinity of Arrowhead station eastward, and, as is to be expected, the drill penetrates a succession of sand and of coarse and fine gravel strata with only here and there a thin bed of clay, or sandy clay or hardpan. The important element in artesian conditions, the superincumbent impervious cover, is absent from the records here, and it is quite unlikely that it would be found at any depth.

The wells drilled in the Lytle Creek wash likewise show a preponderance of coarse material, with only an occasional bed of clay or of cement, the latter acting in many cases as the impervious cap. In the group of wells about the old cienaga a few feet of peaty soil, representing the swamp growth on the original site of the springs, is penetrated by the drill near the surface. One record gives the depth of this organic matter as 24 feet.

The records discussed thus far have been exclusively from the later alluvium, which fills the present valley bottoms and is much more important as a source of water than the older folded beds of the earlier alluvium.

of the important streams—Lytle Creek, Cajon Creek, East Twin Creek, City Creek, Plunge Creek, Mill Creek, and Santa Ana River—flow out upon the later alluvium and sink into it. The older alluvium gets only the local rainfall and the drainage from the southern slope of the San Bernardino Mountains between Mill Creek and San Gorgonio Pass. The amount of water seeking underground passage through the older beds is many times less than that which is concentrated in the later, so that whatever carrying and scouring power water percolating underground may have to clear bowlder beds of their fine interstitial material is much more efficiently exerted in the later than in the older beds.

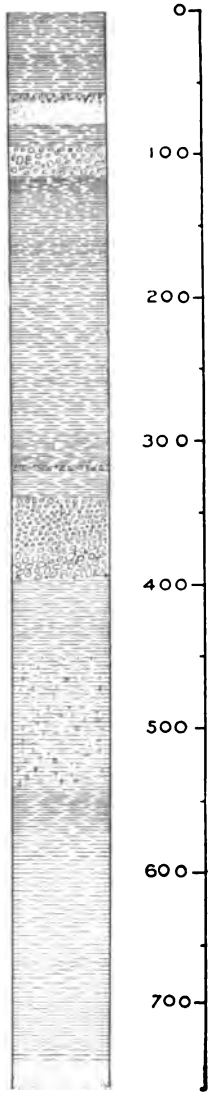


FIG. 8.—Section of Frink Brothers' well in Yucaipe Canyon.

It is to be remembered also that the earlier alluvium is the product of erosion brought into play by a less pronounced relief than that of the present, and therefore less vigorous and yielding finer material. This condition may have had its influence in bringing about the differences which exist between the two deposits.

The abrupt changes from conditions under which extensive coarse bowlder beds were deposited to those resulting in the deposition of fine clays, as shown in the well sections of the San Bernardino cienaga, admit of two or three explanations. Minor phenomena of this character are probably adequately accounted for on the hypothesis of shifting river channels. There are abundant historical examples of limited action of this kind, if historical proof were needed, but the existence of an alluvial fan is itself proof that the stream which built it has at different periods flowed down different radii of the fan. A stream on a growing fan is constantly building up its bed. As soon as that bed becomes enough higher than an adjacent tract to give the latter a steeper grade, the stream during some flood will break through the low confining banks which it has built and flow in the more advantageous channel until that has been built high enough to be abandoned in turn for a lower course. Thus the fans grow. The process is most obvious in the upper, steeper parts, where stream action is the paramount force. It is probably essentially the same in its lower course, but with less abrupt and violent action and more effective modification by other agencies, such as the growth of vegetation and the formation

of wind-blown sand dunes. Yet in most cases it is very effective here. The action of these arid-land streams during the periods of flood is like that of normal streams in that the greatest volume of water, the

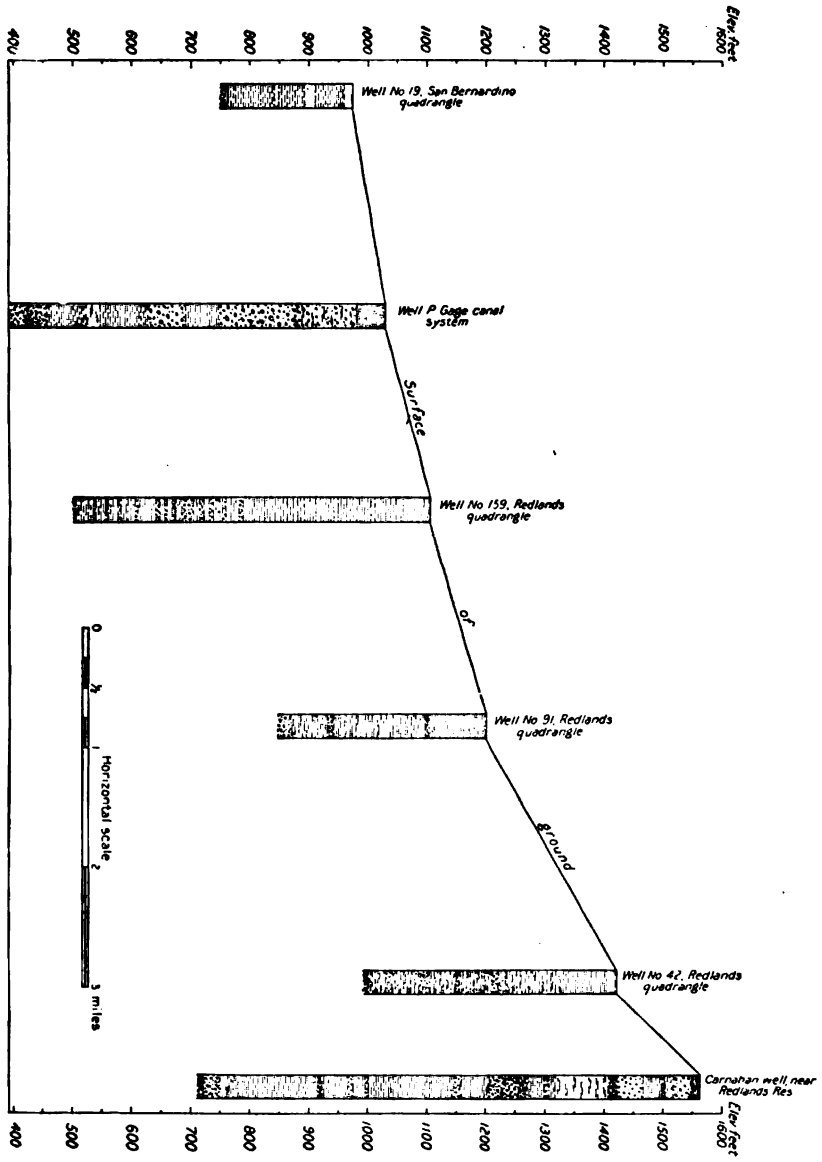



Fig. 9.—Well sections along line G-H, Pl. XII

swiftest current, and the greatest carrying power are concentrated in a main channel and a more moderate current and a greatly lessened carrying power are found outside of this channel on the adjacent

flooded lands. Coarse and heavy material is therefore transported and finally deposited in the channel, while only fine material is carried out over the adjacent flood plain. A train of coarse gravel may thus extend from the head of the fan far down the stream's course, while on either side of it the contemporaneous deposits are fine silts which eventually harden into impervious clays. When a river channel shifts in the growth of the fan in the manner sketched above, what was formerly the river bed may be abandoned entirely or be reached only by the thin edge of the flood waters, which deposit only sands or fine silts. These are in this manner laid down over previously deposited gravels, producing the sharp alternations which the well sections often reveal.

Where deep and laterally extensive bodies of gravel exist beneath the present surface, such as the one which underlies the Victoria tract of the Gage Canal Company and apparently extends west in the direction of Colton as far as the Bunker Hill dike, their presence at least suggests climatic conditions at the time of deposition which were different from those of the present.

Now, gravels are deposited only in the narrow washes which form the channels of the streams and only as incidents of the major floods. In the lower part of the Santa Ana wash, at present, the greater part of the surface alluvium is sand, bowlders and coarse gravels being relatively unimportant. But the gravel stratum under consideration, which is from 100 to 200 feet thick over an area of at least one and probably of several square miles, appears from the drill records to be even coarser and heavier than the surface wash. Seemingly the conditions which resulted in the deposition of the latter are scarcely adequate to account for these coarse cobbles. It may be that slight differences in climate existed when these gravels were laid down. An increase of a few inches in the annual rainfall at present would greatly stimulate stream activity and result in transporting coarse material to much greater distances from the canyon mouths than now. Especially would this be true if such a period of increase were to follow one of drought, during which the fans were steepened by the dropping of stream loads on the upper slopes because of the decreased transporting power due to the lessened rainfall. These periods of increased and lessened rainfall, if they really are to be regarded as one of the causes of the alternation of coarse and of fine deposits, must have been centuries long. Measured in inches, the accumulations by river deposition are very slight for any single year. One or two hundred feet even of coarse alluvium must have required at least as many years to accumulate as there are feet of material, and the finer deposits represent a much longer time, as they represent slower deposition. Yet, geologically, the time required for the filling of the entire San Bernardino basin has been but short. Well-preserved trunks of trees are cut by the drill at depths of several hundred feet. They are dark-

ened and perhaps somewhat flattened by the weight of superincumbent material, but are not otherwise greatly altered. They have been buried centuries, perhaps, but scarcely epochs

### THE CIENAGA.

The streams of an arid or semiarid region normally exist as surface flows only within the mountain valleys where there is no heavy accumulation of wash over the bed rock. As soon as they reach a point where a considerable mantle of débris exists they sink to bed rock or to the ground-water level and continue their course by percolation through the porous accumulations. This was the habit of all streams tributary to San Bernardino Valley previous to their appropriation at the canyon mouths for irrigation purposes. Only a part of the rarer floods following heavy winter rains reach the sea over the surface. Whenever in their subterranean course the waters encountered an impervious barrier of any kind, they accumulated behind it until they rose to its level and flowed over it, precisely as stream waters are ponded back of a dam until they rise to the level of its crest. When such an obstruction extended to the surface of the ground the waters were forced out as springs and again became surface flows. In southern California these lands of rising waters are given the old Spanish name "cienaga."

Generally in the alluvial material where ground waters exist under pressure the compact stratum, whatever be its nature, which confines them is not entirely impervious. There is leakage through it, and the leaks, when they extend to the surface, become the springs which characterize the cienaga lands. In almost every instance those lands which, as the region developed, became important artesian basins were recognized as moist land before development through the occurrence of these springs, but, although the cienagas in so many cases proved to indicate artesian conditions, and the greater artesian basins were always indicated by them, a few of the minor basins are not thus marked, and the distribution of the springs in the important basins sometimes fails to give any adequate guide to the extent or outlines of the artesian area. It is rare, of course, that a subsurface dam extends just near enough to the surface to force the percolating waters out without expressing itself topographically. A ridge, or at least a series of mounds, is apt to be found athwart a stream's course along the lower limit of the cienaga (Pl. XI). The lands just above this are flat and often ill drained. The waters rising and evaporating here, under the influence of the effective southern sun, leave behind them their salt content, and thus alkali lands may result. They are, perhaps, less characteristic of the valley cienagas than of the rarer and less extensive examples occurring in the desert. The drier air and the fiercer heat here, acting

upon a smaller water supply, cause a relatively much larger evaporation and result in the deposition of a greater percentage of the contained alkalies. These, in some instances, act as a firm cementing material, particularly where calcium carbonate is an abundant salt, so that the site of the spring may be built up into a low alkaline terrace, which interrupts the even slopes of the desert wash. The Box Springs, just north of the San Bernardino Mountains, are an example of this class of cienaga.

### UNDERGROUND CIRCULATION.

A fact which has already been frequently mentioned is that the waters of the living mountain streams during periods of normal flow disappear promptly in the gravels at the mouths of the mountain canyons. The greater discharges of the minor floods are likewise usually absorbed before they have passed far out upon the stream washes. Only a part of the infrequent greater floods escapes to the sea as a surface flow. These absorbed normal and flood waters percolate slowly seaward underground along courses which are determined by the extent and permeability of the valley filling and by the presence or absence of impervious obstructions, such as buried or partly buried bed-rock masses, or of folds in the alluvium itself, which may deflect or obstruct the waters.

When experiments have been made to determine the rate and direction of movement in the ground waters, it has usually been found that the flow is in the direction in which the general water plane slopes, although local exceptions may exist. The general position and attitude of this plane in San Bernardino Valley have been determined at two periods (Pl. VII). Its slope, although not uniform, is general toward the lowest part of the valley occupied by the Santa Ana wash. It is in the same direction, although not at the same rate, as the surface gradient. The seepage of the underground waters, which is generally slow, although at a varying rate, is, like the surface slope, toward the lowest point of the basin. The rate of seepage, however, is much greater along the lines of the porous gravels which mark the washes of the present and of the past than in the interareas of sand and soil and clay. So great is the difference in rate that it seems likely that the form of the water surface undergoes a more or less regular annual alteration. It is believed to arch along the line of the washes during the rainy season, draining slowly from these laterally, toward the less pervious areas on either side. During the dry season, on the other hand, when the open material of the washes, draining freely because of its porosity, loses its waters before the adjacent soils, the surface of the water plane is depressed in the vicinity of the washes. The adjacent lands then drain toward the washes, as they drain away from them during the wet season. Such

a zone in which there is a seasonal reversal of the direction of percolation may be expected to border the loose gravels of all flood-water channels (fig. 10).

The checking of the rate at which the water moves seaward, as soon as it sinks into the rubble of the valley alluvium, together with the fact that the porous buried strata through which it percolates have no definite banks as have surface streams, results in the spreading out of the water beneath the surface into a broad zone through which it moves seaward at varying rates. In San Bernardino Valley these zones, representing the percolation from the mountain tributaries, Lytle Creek, Cajon Creek, Devil Canyon, East Twin Creek, Plunge Creek, and Santa Ana River and Mill Creek, and in winter from the direct rainfall within the valley itself, converge in the basin about San Bernardino into the wide, irregular area 40 or 50 square miles in extent and situated near the center of the valley, which is especially valuable because of the accessibility of its stored water.

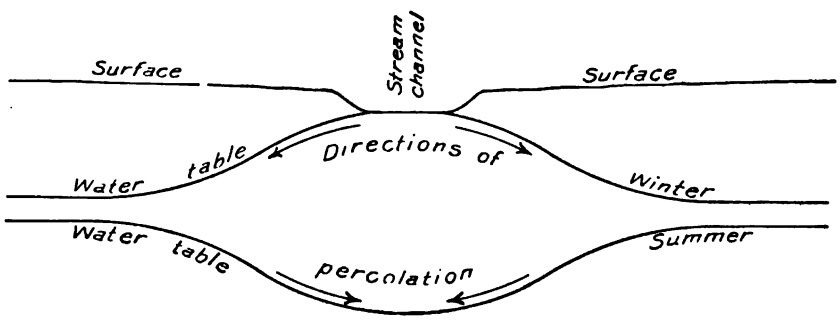



FIG. 10.—Diagrammatic cross section of summer and winter water table beneath a stream channel.

The interareas between these zones, where they are saturated, probably receive their waters, in part at least, by lateral seepage from the zones themselves. The rate of movement through the gravels in San Bernardino Valley has not been investigated. Measurements of the rate where comparable conditions exist have been made by Prof. C. S. Slichter[a] in Mohave River near Victorville, Cal., and in the Paso de Bartolo, through which the waters of the San Gabriel flow; and by Mr. Homer Hamlin[b] in Los Angeles River in and above Los Angeles, Cal. At Victorville velocities of 6, 8, 20, 35, 48, and 64 feet a day were determined, and an average of 50 feet has been assumed. In the Paso de Bartolo the much lower rates of 3½, 4, 5½, and 7 feet a day were determined. In the extensive series of tests made by Mr. Hamlin, extremes ranging between 0 and 96 feet a

[a] Slichter, Charles S., The motions of underground waters. Water-Sup. and Irr. Paper No. 67, U. S. Geol. Survey, 1902, p. 43 et seq.

[b] Hamlin, Homer, Underflow tests in the drainage basin of Los Angeles River: Water-Sup. and Irr. Paper No. 112, U. S. Geol. Survey, 1905.

day were measured. Measurements were attempted on many strata which gave results lower than could be detected by the methods used. Mr. Hamlin believes that his methods are sufficiently refined to measure a movement of less than 1 foot a day, so that where no flow was detected it is assumed that the alluvium is practically impervious.

The average flow in 26 of Mr. Hamlin's tests, all of which gave measurable rates of movement, is 23 feet a day in round numbers. Since the majority of these tests were made in the narrows of Los Angeles River, 20 miles below the mouth of Tujunga Canyon, it may be assumed that at least as high an average velocity is maintained through the pervious strata in the Santa Ana River wash above Colton. It may be, indeed, that a higher average is maintained there. Twenty-three feet a day is 8,395 feet, or a little more than 1½ miles a year. At this rate waters which enter the gravels at the head of the Santa Ana wash would appear at the Bunker Hill dike seven or eight years later. The facts probably are that a portion of these waters appears there in very much less time, while another portion, passing through less pervious strata, requires a much longer time. The effective percolation is always that of the greater rate through the coarser material, since its discharge of available water is vastly greater than that of the slower percolation.

The fact that the water plane all over the basin responds promptly to an increase of rainfall is not an argument against the deliberate movement of the underground water. The water plane rises as a hydrostatic effect of the introduction of more water at any point within the basin and not as a result of flow from the point of entry to all the points affected.

The rate at which flood waters are absorbed by the alluvial gravels and the total amount thus added to the underground reservoirs by any given storm are matters of great interest but are difficult to determine. Mr. W. B. Clapp, hydrographer, conducted a series of measurements of a number of streams in southern California during the spring of 1903 to determine the rate of absorption of flood waters. On April 16 of that year a moderate rain accompanying a low temperature resulted in a small flood discharge and a well-maintained later flow, as much of the precipitation was in the form of snow at the greater altitudes. On April 24 the streams discharging into the San Bernardino basin were measured and the proportions of this flow diverted and absorbed were determined. The measurements were made with a limited force, and therefore it was not possible to carry them out at as many points as was desired. Nevertheless the results are of great interest. Similar measurements were made on May 16 and the results of both are shown in the accompanying table, which gives the total amount of water absorbed by the alluvium during the two twenty-four-hour periods.

*Amount of water discharged in twenty-four hours from tributary streams and sinking in Santa Ana River basin above Colton, Cal.*

[W. B. Clapp, hydrographer.]

APRIL 24, 1903.

| Stream. | Diversions. | Waste. | Diversions. | Waste. | Total. | |
|---|---|---|---|---|---|---|
| | *Cubic feet.* | *Cubic feet.* | *Acre-feet.* | *Acre-feet.* | *Cubic feet.* | *Acre-feet.* |
| Santa Ana | 1,382,400 | 10,022,400 | 32 | 230 | 11,404,800 | 262 |
| Mill Creek | 432,000 | 6,998,400 | 10 | 161 | 7,430,400 | 171 |
| Plunge Creek | ..... | 1,987,200 | ..... | 46 | 1,987,200 | 46 |
| City Creek | ..... | 1,900,800 | ..... | 44 | 1,900,800 | 44 |
| East Twin Creek | ..... | 864,000 | ..... | 20 | 864,000 | 20 |
| West Twin Creek | ..... | 743,040 | ..... | 17 | 743,040 | 17 |
| Lytle Creek | 561,600 | 4,881,600 | 13 | 112 | 5,443,200 | 125 |
| Total | 2,376,000 | 27,397,440 | 55 | 630 | 29,773,440 | 685 |

MAY 16, 1903.

| | | | | | | |
|---|---|---|---|---|---|---|
| Santa Ana | 4,060,800 | 4,147,200 | 93 | 95 | 8,208,000 | 188 |
| Mill Creek | 4,233,600 | 1,641,600 | 97 | 38 | 5,875,200 | 135 |
| Plunge Creek | 518,400 | 259,200 | 12 | 6 | 777,600 | 18 |
| City Creek | 604,800 | 345,600 | 14 | 8 | 950,400 | 22 |
| East Twin Creek | 172,800 | 259,200 | 4 | 6 | 432,000 | 10 |
| West Twin Creek | 172,800 | 172,800 | 4 | 4 | 345,600 | 8 |
| Lytle Creek | 1,296,000 | 1,209,600 | 30 | 28 | 2,505,600 | 58 |
| Total | 11,059,200 | 8,035,200 | 254 | 185 | 19,094,400 | 439 |

The rate at which this absorption took place is indicated for one of the streams, the Santa Ana, by fig. 11. During the earlier measurement, that of April 24, a flood of 197 second-feet was completely absorbed in 8 miles, while on May 16 a flow of 67 second-feet had disappeared within a distance of 5 miles, more than one-third of the loss occurring in the last half mile, when the velocity was least.

During the first measurement water from the measured streams was flowing into the underground reservoir at the rate of about 317 cubic feet a second, and during the last measurement at the rate of about 100 cubic feet a second. It is of interest to note that the first rate is somewhat more than double that at which water is withdrawn from the same basin during the irrigating season, while the later measurement indicates absorption at a rate equal to two-thirds of the rate of withdrawal during the irrigating season. During great floods this recharge must take place at a very much greater rate, but it is evident that this

is necessary, since it continues for a comparatively brief period, while the withdrawals are continuous for nine or ten months of the year.

### ORIGIN OF HEAD WITHIN THE ARTESIAN BELT.

The alluvial deposits of the streams tributary to the San Bernardino basin have been laid down by the streams as they have built the sloping plain upon which they now flow. All of the deposits, fine and coarse, therefore have a distinct dip toward the lowest part of the basin. All of these strata abut against the arch in the earlier alluvium, which is known as the Bunker Hill dike. Where coarse beds in the lower part are capped by finer ones, which either are

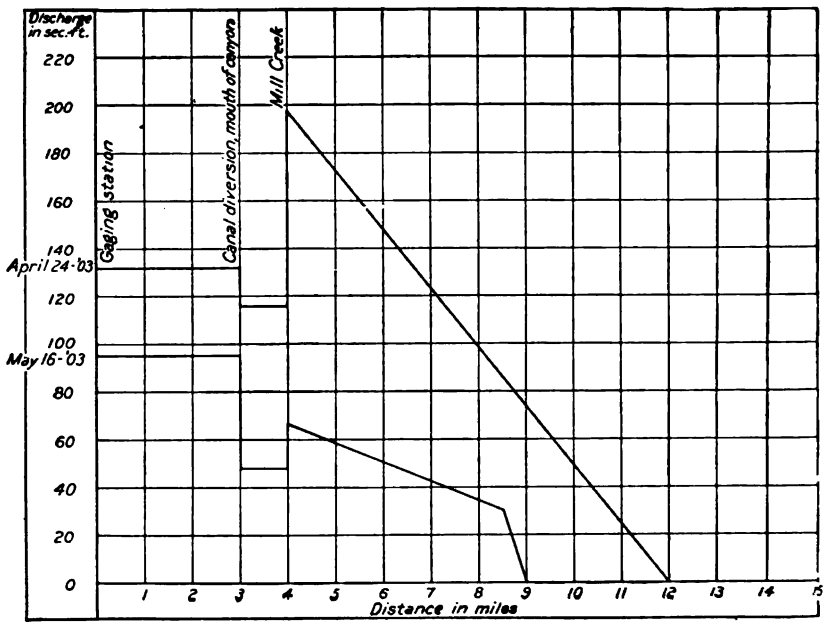



FIG. 11.—Diagram showing sinking of flood waters of Santa Ana River in stream bed.

impervious or are so compact that water leaks upward through them more slowly than it enters the coarse underlying strata, artesian conditions result. As the gravel and bowlder beds and the finer overlying clays and sands occur at a number of horizons, water under pressure is found at a number of depths within the artesian area. The wells whose yield has been greatest are of moderate depth. Three of the Gage wells, all less than 200 feet deep, flowed more than 400 inches of water each in 1892. Four others are reported to have yielded near 300 inches each in the same time. Two of these wells were 300 feet deep or less, one was 426 feet, and another 582 feet deep. All have ceased flowing or have greatly decreased in yield, but the shallower ones were the earliest exhausted. One of the best yielding wells of the

Riverside Water Company originally was a 330-foot well in the tract which furnishes the city of Riverside with its domestic supply. Two other famous wells belonging to the water company, about 2 miles east of San Bernardino, flowed between 150 and 200 inches of water each when they were first put down. They were drilled in 1900, and have been among the most productive of the late wells. The yield from them has fallen off greatly of late, but they have not ceased to flow. One of the new wells put in by the city of San Bernardino in the Antill tract in 1904 measured at the time of its completion somewhat more than 90 inches. A 984-foot well belonging to the Riverside Water Company, situated near the intersection of Waterman avenue and Third street, and yielding about 120 inches, is now one of the strongest flowing wells in the valley, although earlier wells have at some time flowed several times as much. The experiences of the water companies go to show that while the coarsest gravels and the freest flows have been secured at very moderate depths, the head under which these waters exist is easily drawn down. The deeper wells are more lasting, although usually more moderate in their first yield.

A not unusual experience in San Bernardino Valley is to secure a first flow from a shallow well 100 or 200 feet deep, and after this has ceased to flow with the lapse of years, to sink a deep well in the same vicinity and again secure a satisfactory flow from a lower horizon. The direct inference from these phenomena is that the water-bearing beds are separated by intervening strata of clay or fine sand, and so are independent sources of water under different heads. Another hypothesis advanced by the engineers of the district is that all the waters of the basin are under the same head, originating in the lowest artesian stratum, but that much pressure is lost through frictional resistance, as these waters rise from the lowest level through fine-grained beds to the coarse beds above; when they are tapped at a higher level, therefore, they are under much less pressure than when tapped at deeper points. This hypothesis requires that all pressures originate in a lower bed, and means that all of the artesian waters within the San Bernardino cienaga rise from this lowest horizon.

The other hypothesis, that of separate water horizons with independent intakes—those of the shallower beds well down from the canyon mouths toward the center of the basin, those of the deeper beds farther up toward the head of the alluvial fan—supposes all the waters to be simply percolating waters at any horizon, which have been caught beneath the upstream edges of the various impervious clay masses as they have worked seaward. Since these clays exist at various horizons, their confined waters are tapped at various depths.

To determine which of these hypotheses is correct would require a series of carefully conducted experiments upon the interdependence

of deep and shallow wells. The experiments first conducted by Professor Hilgard[a] upon the interdependence of the wells of the Gage canal system in 1889 throw no light upon the relations existing between wells of greater and of less depth, since the only wells available for measurements and in any way involved at that time were the early shallow bores less than 200 feet deep.

The later extensive series of records made by the engineers of the Gage system in the fall of 1892 upon the 55 wells which were the source of supply for the canal at that time, while not carried out with the idea of distinguishing between deep and shallow wells, or of showing the interdependence of these grouped according to their depth, do throw some light upon the problem. The essential results of these measurements are assembled in the following table:

*Records of wells of Gage canal system, San Bernardino, Cal.*

| Quadrangle. | No. of well. | Serial No. | Distance of nearest well. | Depth of well. | Elevation. | Size of well. | Temperature of water. | Original measurements. | Final measurements. | Per cent decrease from original to final measurements. | Cumulative total of original measurements. | Cumulative total of final measurements. | Percentage of loss in final total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Yards.* | *Feet.* | *Feet.* | *In.* | *° F.* | *Miner's inches.* | *Miner's inches.* | | | | |
| San Bernardino. | 115 | 1 | 0 | 656 | 1,033.15 | 10 | 75 | 5.00 | 5.00 | 0 | 5.00 | 5.00 | 00 |
| Do.... | 116 | 2 | 1,216 | 534 | 1,033.63 | 10 | 74 | 46.00 | 32.50 | 30 | 51.00 | 37.50 | 27 |
| Do.... | 117 | 3 | 296 | 582 | 1,033.75 | 10 | 74 | 37.00 | 29.00 | 22 | 88.00 | 66.50 | 24.5 |
| Do.... | 118 | 4 | 525 | 482 | 1,033.96 | 10 | 74 | 48.75 | 41.25 | 15 | 136.75 | 107.75 | 21.5 |
| Do.... | 119 | 5 | 561 | 320 | 1,034.19 | 10½ | 73 | 3.50 | 3.50 | 00 | 140.25 | 111.25 | 21 |
| Do.... | 120 | 6 | 265 | 784 | 1,034.29 | 10 | 74 | 51.75 | 45.00 | 13 | 192.00 | 156.25 | 19 |
| Do.... | 121 | 7 | 4,620 | 196 | 1,036.14 | 10½ | 70 | 27.50 | 13.75 | 50 | 219.50 | 170.00 | 23 |
| Do.... | 122 | 8 | 353 | 190 | 1,036.28 | 10½ | 70 | 46.00 | 21.00 | 55 | 265.50 | 191.00 | 28 |
| Do.... | 123 | 9 | 204 | 142 | 1,036.36 | 10 | 70 | 9.75 | 3.50 | 64 | 275.25 | 194.50 | 29 |
| Do.... | 124 | 10 | 321 | 148 | 1,036.49 | 10½ | 68.5 | 6.00 | 3.25 | 46 | 281.25 | 197.75 | 30 |
| Do.... | 125 | 11 | 714 | 141 | 1,036.78 | 7 | 67 | 58.00 | 24.50 | 58 | 339.25 | 222.25 | 35 |
| Do.... | 126 | 12 | 80 | 181 | 1,036.81 | 7 | 68 | 49.75 | 21.62 | 57 | 389.00 | 243.37 | 37.5 |
| Do.... | 127 | 13 | 765 | 426 | 1,037.12 | 10 | 70 | 150.00 | 86.50 | 43 | 539.00 | 330.37 | 39 |
| Do.... | 128 | 14 | 530 | 472 | 1,037.33 | 10 | 70 | 162.00 | 101.50 | 37 | 701.00 | 431.87 | 39 |
| Do.... | 129 | 15 | 1,680 | 518 | 1,048.22 | 10 | 64.5 | 80.50 | 62.50 | 23 | 781.50 | 494.37 | 37 |
| Do.... | 130 | 16 | 180 | 388 | 1,048.66 | 10 | 66 | 60.50 | 50.00 | 18 | 842.00 | 544.37 | 36 |
| Do.... | 131 | 17 | 175 | 380 | 1,049.23 | 10 | 65 | 37.50 | 32.00 | 15 | 879.50 | 576.27 | 35 |
| Do.... | 132 | 18 | 480 | 386 | 1,049.44 | 10 | 62 | 71.50 | 27.00 | 63 | 951.00 | 603.37 | 37 |
| Do.... | 133 | 19 | 330 | 198 | 1,052.44 | 10 | 62 | 143.00 | 43.50 | 70 | 1,094.00 | 646.87 | 43 |
| Do.... | 134 | 20 | 270 | 124 | 1,056.94 | 10 | 62 | 60.00 | 9.50 | 84 | 1,154.00 | 656.37 | 44 |
| Do.... | 135 | 21 | 260 | 116 | 1,055.16 | 10 | 62 | 104.00 | 24.75 | 77 | 1,258.00 | 681.12 | 46 |
| Do.... | 136 | 22 | 270 | 134 | 1,056.75 | 10 | 62 | 146.00 | 50.50 | 66 | 1,404.00 | 731.62 | 48 |
| Redlands. | 391 | 23 | 265 | 168 | 1,057.81 | 10 | 62 | 132.50 | 36.00 | 73 | 1,536.00 | 767.62 | 5[illegible] |
| Do.... | 392 | 24 | 265 | 166 | 1,058.67 | 10 | 62 | 68.75 | 26.00 | 62 | 1,605.25 | 793.62 | 5[illegible] |
| Do.... | 393 | 25 | 320 | 152 | 1,060.88 | 10 | 62 | 68.75 | 19.75 | 71 | 1,674.00 | 813.37 | 52 |
| Do.... | 394 | 26 | 280 | 123 | 1,063.34 | 10 | 62 | 75.00 | 21.00 | 72 | 1,749.00 | 834.37 | 54 |
| Do.... | 395 | 27 | 320 | 125 | 1,065.60 | 10 | 62 | 34.00 | 9.00 | 73 | 1,783.00 | 843.37 | 54 |

[a] Hilgard, E. W., Subterranean water supply of the San Bernardino Valley: Bull. No. 119, Office of Exp. Sta., U. S. Dept. Agric., p. 116.

*Records of wells of Gage canal system, San Bernardino, Cal.*—Continued.

| Quadrangle. | No. of well. | Serial No. | Distance of nearest well. | Depth of well. | Elevation. | Size of well. | Temperature of water. | Original measurements. | Final measurements. | Per cent decrease from original to final measurements. | Cumulative total of original measurements. | Cumulative total of final measurements. | Percentage of loss in final total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Yards.* | *Feet.* | *Feet.* | *In.* | ° *F.* | *Miner's inches.* | *Miner's inches.* | | | | |
| Redlands. | 396 | 28 | 280 | 144 | 1,062.28 | 10 | 62 | 88.50 | 38.00 | 58 | 1,871.50 | 881.37 | 53 |
| Do.... | 397 | 29 | 310 | 140 | 1,064.27 | 10¼ | 62 | 47.00 | 28.85 | 39 | 1,918.50 | 910.22 | 53 |
| Do.... | 398 | 30 | 790 | 138 | 1,075.05 | 10 | 62 | 30.00 | 11.25 | 63 | 1,948.50 | 921.47 | 53 |
| Do.... | 399 | 31 | 430 | 106 | 1,074.58 | 10 | 64 | 9.50 | 3.75 | 60 | 1,958.00 | 925.22 | 53 |
| Do.... | 400 | 32 | 35 | 130 | 1,074.28 | 10 | 64 | 28.50 | 16.25 | 48 | 1,986.50 | 941.47 | 53 |
| Do.... | 401 | 33 | 315 | 146 | 1,070.72 | 10 | 63 | 90.00 | 41.00 | 55 | 2,076.50 | 982.47 | 53 |
| Do.... | 402 | 34 | 550 | 116 | 1,064.69 | 10 | 63 | 98.30 | 48.00 | 52 | 2,174.80 | 1,030.47 | 53 |
| Do.... | 403 | 35 | 130 | 134 | 1,063.49 | 10 | 63 | 65.75 | 30.50 | 54 | 2,240.55 | 1,060.97 | 53 |
| Do.... | 404 | 36 | 120 | 116 | 1,060.89 | 10 | 64 | 29.50 | 16.00 | 46 | 2,270.05 | 1,076.97 | 53 |
| Do.... | 405 | 37 | 680 | 147 | 1,057.05 | 10 | 66 | 92.00 | 42.00 | 55 | 2,362.05 | 1,118.97 | 54 |
| Do.... | 406 | 38 | 90 | 122 | 1,058.15 | 10 | 66 | 48.75 | 28.75 | 41 | 2,410.80 | 1,147.72 | 58 |
| Do.... | 407 | 39 | 279 | 115 | 1,059.01 | 10 | 66 | 24.75 | 10.50 | 58 | 2,435.55 | 1,158.22 | 53 |
| Do.... | 408 | 40 | 1,090 | 169 | 1,058.14 | 10¼ | 66 | 166.00 | 77.15 | 53 | 2,601.55 | 1,235.37 | 53 |
| San Bernardino. | 155 | 41 | 474 | 193 | 1,050.54 | 10 | 66 | 168.00 | 69.50 | 58 | 2,769.55 | 1,304.87 | 53 |
| Do.... | 156 | 42 | 510 | 192 | 1,046.29 | 10 | 66 | 169.00 | 85.75 | 50 | 2,938.55 | 1,390.62 | 53 |
| Do.... | 157 | 43 | 510 | 390 | 1,044.13 | 10¼ | 66 | 137.00 | 109.75 | 20 | 3,075.55 | 1,500.37 | 52 |
| Do.... | 158 | 44 | 307 | 224 | 1,041.76 | 10 | 64 | 146.00 | 92.75 | 37 | 3,221.55 | 1,593.12 | 51 |
| Do.... | 159 | 45 | 1,580 | 123 | 1,044.87 | 7 | 62 | 46.25 | 16.50 | 60 | 3,267.80 | 1,609.62 | 51 |
| Do.... | 160 | 46 | 15 | 133 | 1,044.87 | 7 | 62 | 16.75 | 6.70 | 60 | 3,284.55 | 1,616.32 | 51 |
| Do.... | 161 | 47 | 15 | 133 | 1,045.02 | 7 | 62 | 66.00 | 26.40 | 60 | 3,350.55 | 1,640.72 | 52 |
| Do.... | 162 | 48 | 40 | 139 | 1,047.67 | 5 | 62 | 50.84 | 29.33 | 60 | 3,401.34 | 1,670.05 | 51 |
| Do.... | 163 | 49 | 50 | 211 | 1,047.87 | 7 | 62 | 76.00 | 26.40 | 60 | 3,477.39 | 1,698.45 | 52 |
| Do.... | 164 | 50 | 40 | 100 | 1,046.42 | 7 | 62 | 20.00 | 15.00 | 25 | 3,497.39 | 1,713.45 | 51 |
| Redlands. | 409 | 51 | 4,440 | 127 | 1,077.27 | 7 | 64 | 7.00 | .00 | 100 | 3,504.39 | 1,713.45 | 52 |
| Do.... | 410 | 52 | 20 | 127 | 1,076.83 | 7 | 64 | 7.10 | .00 | 100 | 3,511.49 | 1,713.45 | 52 |
| Do.... | 411 | 53 | 25 | 125 | 1,077.14 | 7 | 64 | 7.00 | .00 | 100 | 3,518.49 | 1,713.45 | 52 |
| Do.... | 412 | 54 | 25 | 125 | 1,077.45 | 7 | 65 | 10.50 | .00 | 100 | 3,528.99 | 1,713.45 | 52 |
| San Bernardino. | 169 | 55 | 5,070 | 300 | 1,086.71 | 10 | 64 | 150.00 | 80.00 | 56 | 3,678.99 | 1,793.45 | 52 |

The total flow when all the wells were open was 52 per cent less than the cumulative total yielded by adding the results obtained by measuring each well when all others were closed. If the wells are grouped according to depth, however, some significant relations are brought out.

Of the 55 wells, 39 are less than 200 feet deep. The decrease in the individual flow of these wells from a maximum, when all but one are closed, to a minimum, when all are open, ranges from 25 to 100 per cent, and the total when all are open is 62 per cent less than the cumulative total. Eleven of the 55 wells are between 200 and 500 feet deep. The decrease in the flow of individual wells in this group, resulting from the opening of all the wells, varied between 0 and 63 per cent, and the falling off from the cumulative total to the final

total was 33 per cent, about half that of the much larger group of shallower wells. A third group of 5 wells, ranging in depth from 500 to nearly 800 feet, showed individual decreases in flow, as the other wells were opened, from 0 to 37 per cent, with an average of 1[illegible] per cent—much less than either of the shallower groups. When the wells are grouped in this way and the data examined, it is clear that, on the whole, the deep and the shallow wells behaved very differently during the tests.

The shallowest wells, forming the largest group, show the greatest individual and average decrease; a second group, intermediate in number of wells and in depth, shows an intermediate decrease; while the smallest group, consisting of the deepest wells, shows the least falling off in yield as the other wells are opened.

It seems safe to conclude from this showing that there is not free connection between the shallower and the deeper water-bearing horizons; indeed, the wells of each group behave much as would be expected if they tapped wholly independent sources of water. It is not probable, however, that this is true. The irregular character of the alluvial deposits, the abundant unconformities and local channels within them, and the fact that each bed of clay and gravel is probably quite limited in lateral extent, make it probable that imperfect and devious connections exist between the deeper and the higher water-bearing horizons. The alluvial fans do not give the ideal artesian conditions of a practically impervious cover and a pervious underlying stratum, but rather of a less pervious superincumbent bed and a more pervious water-carrying bed below. Just as the water leaks through the topmost clay cap of the Warm Creek and Santa Ana basins to the surface as springs, so it probably leaks from the lower horizons into the upper. So long as this leakage is less rapid than the supply of water to the bed through natural sources, pressure will be maintained and artesian conditions will continue. Imperfect connection of this sort probably exists between the chief water-bearing horizons throughout the artesian basin, and it may account for the reported sensitiveness of deep or shallow flowing wells to pumping in shallow or deep ones near by.

### DECLINE OF THE WATERS.

Water users throughout the valley have felt in various ways the general diminution of the supply of underground waters within the last ten years. The large irrigating and domestic companies have been affected through the lessened flow of surface streams upon which they formerly depended for a large part of their supply or through the diminished yield of wells and the necessity of installing pumping plants where originally naturally flowing waters sufficed.

Local users, ranchers, and others have found that lands formerly

moist enough for pasture and ordinary crops are now dry and require irrigation, and that domestic wells must be frequently deepened in order to follow the declining ground water. In some cases the question of supply is becoming acute and the increased cost of water almost prohibitive for certain crops in unfavorable localities. Personal bitterness often results and suits are instituted to prevent developments on adjacent land.

About the general fact of the decline of the ground waters and of the lessened flow of wells there is no dispute (fig. 12 and Pl. VII). The relation of this decline to decreased rainfall on the one hand and to the drafts upon the stored underground waters through developments of various kinds upon the other is a subject of earnest discussion, and, indeed, upon a correct answer to it must depend the future attitude of the citizens toward further reclamation of lands and toward the successful maintenance of a part of those already reclaimed.

*Changes in water level in wells in Redlands quadrangle between 1900 and 1904.*

| No. of well. | Owner. | Location. | Elevation of surface. | Elevation of water. 1900. | Elevation of water. 1904. | Change in water level. |
|---|---|---|---|---|---|---|
| | | | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| 1 | Doctor Meeker | Sec. 16, T. 1 S., R. 2 W. | 1,996 | 1,718 | Dry. | − 3+ |
| 2 | Ward, Mills & Co | Sec. 21, T. 1 S., R. 2 W. | 2,005 | 1,933 | 1,955 | +22 |
| 6 | Mrs. M. A. Brown | Sec. 22, T. 1 S., R. 2 W. | 2,250 | 2,225 | 2,223 | − 2 |
| 7 | R. P. McIntosh | Sec. 20, T. 1 S., R. 2 W. | 1,910 | 1,818 | 1,832 | +14 |
| 9 | L. Lyons | Sec. 16, T. 1 S., R. 2 W. | 2,075 | 2,052 | 2,062 | +10 |
| 14 | W. J. French | Sec. 19, T. 1 S., R. 2 W. | 1,720 | 1,560 | 1,556 | − 4 |
| 28 | Garland estate | Sec. 25, T. 1 S., R. 3 W. | 1,570 | 1,394 | (a) | −29+ |
| 42 | C. L. Hayes | Sec. 27, T. 1 S., R. 3 W. | 1,420 | 1,270 | (b) | −30+ |
| 43 | O. W. Harris | Sec. 34, T. 1 S., R. 3 W. | 1,503 | 1,363 | (c) | − 3+ |
| 45 | A. C. Fowler | Sec. 32, T. 1 S., R. 3 W. | 1,250 | 1,140 | Dry. | −60+ |
| 46 | L. C. Smith | do | 1,215 | 1,135 | (d) | −10+ |
| 48 | E. Vache | do | 1,260 | 1,200 | 1,182 | −18 |
| 56 | H. Bermudas | do | 1,210 | 1,156 | 1,187 | +31 |
| 60 | R. T. Curtis | Sec. 29, T. 1 S., R. 3 W. | 1,123 | 1,073 | 1,055 | −18 |
| 66 | Gansnor & Renwick | Sec. 30, T. 1 S., R. 3 W. | 1,140 | 1,110 | 1,085 | −25 |
| 80 | Mrs. S. W. Sylvera | Sec. 29, T. 1 S., R. 3 W. | 1,200 | 1,170 | 1,137 | −43 |
| 83 | S. Mansfield | do | 1,193 | 1,154 | 1,143 | −11 |
| 84 | A. Lenanon | do | 1,186 | 1,156 | 1,131 | −25 |
| 94 | W. A. Nichols | Sec. 28, T. 1 S., R. 3 W. | 1,246 | 1,194 | 1,176 | −18 |
| 102 | Willis Miller | Sec. 21, T. 1 S., R. 3 W. | 1,290 | 1,203 | 1,187 | −16 |
| 109 | C. A. Shaw | do | 1,267 | 1,217 | 1,185 | −32 |
| 113 | A. Gregory | do | 1,245 | 1,194 | 1,175 | −19 |
| 117 | S. Ronzone | Sec. 16, T. 1 S., R. 3 W. | 1,257 | 1,192 | 1,166 | −26 |
| 120 | M. R. Gay | Sec. 17, T. 1 S., R. 3 W. | 1,220 | 1,170 | 1,145 | −25 |
| 123 | J. F. Boyd | Sec. 16, T. 1 S., R. 3 W. | 1,290 | 1,180 | 1,180 | 0 |
| 124 | Wm. Lindenberg | Sec. 20, T. 1 S., R. 3 W. | 1,220 | 1,180 | 1,155 | −23 |
| 125 | H. S. Drew | Sec. 19, T. 1 S., R. 3 W. | 1,167 | 1,133 | 1,137 | + 4 |
| 126 | James Smith | do | 1,164 | 1,130 | 1,113 | − 17 |
| 130 | Clark & Brotherton | Sec. 20, T. 1 S., R. 3 W. | 1,195 | 1,162 | 1,147 | − 15 |
| 131 | J. J. Pendergast | Sec. 29, T. 1 S., R. 3 W. | 1,200 | 1,166 | 1,159 | − 7 |
| 132 | H. H. Cole | Sec. 30, T. 1 S., R. 3 W. | 1,140 | 1,108 | 1,095 | −13 |

[a] Dry at 1,365 feet. [b] 1902, 1,240 feet. [c] 1902, 1,300 feet. [d] Dry at 1,125 feet.

*Changes in water level in wells in Redlands quadrangle between 1900 and 1904*—Continued.

| No. of well. | Owner. | Location. | Elevation of surface. | Elevation of water. 1900. | Elevation of water. 1904. | Change in water level. |
|---|---|---|---|---|---|---|
| | | | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| 129 | H. R. Scott | Sec. 19, T. 1 S., R. 3 W. | 1,120 | 1,108 | (a) | [illegible] |
| 145 | E. F. Van Leuven | Sec. 25, T. 1 S., R. 4 W. | 1,103 | 1,083 | 1,070 | -13 |
| 155 | F. Morris | Sec. 32, T. 1 S., R. 3 W. | 1,260 | 1,195 | 1,165 | -30 |
| 289 | N. Sutherland | Sec. 4, T. 1 S., R. 3 W. | 1,227 | 1,160 | 1,134 | -26 |
| 290 | Pattee & Nye | Sec. 5, T. 1 S., R. 3 W. | 1,200 | 1,150 | 1,126 | -24 |
| 291 | G. J. Fowler | do | 1,180 | 1,127 | 1,110 | -17 |
| 292 | R. F. Cunningham | do | 1,160 | 1,120 | 1,105 | -15 |
| 334 | Mrs. Haws | Sec. 6, T. 1 S., R. 3 W. | 1,125 | 1,125 | 1,115 | -10 |
| 350 | Jane C. Goodman | do | 1,140 | 1,128 | 1,108 | -20 |
| 386 | State of California Hospital | Sec. 5, T. 1 S., R. 3 W. | 1,110 | 1,078 | 1,064 | -14 |

a Dry at 20 feet.

*Changes in water level in wells in San Bernardino quadrangle between 1900 and 1904.*

| No. of well. | Owner. | Location. | Elevation of surface. | Elevation of water. 1900. | Elevation of water. 1904. | Change in water level. |
|---|---|---|---|---|---|---|
| | | | *Feet.* | *Feet.* | *Feet.* | *Feet.* |
| 73 | W. L. Zader | Sec. 29, T. 1 S., R. 4 W. | 980 | 930 | 920 | -10 |
| 76 | Mrs. B. R. Atkins | Sec. 30, T. 1 S., R. 4 W. | 980 | 938 | 923 | -15 |
| 78 | W. G. Soares | do | 875 | 871 | 863 | [illegible] |
| 104 | Riverside Trust Co. | Sec. 24, T. 1 S., R. 4 W. | 1,077 | 1,077 | 1,072 | -5 |
| 178 | G. W. Curtis | do | 1,088 | 1,063 | 1,045 | -18 |
| 181 | W. A. Thomas | do | 1,078 | 1,076 | 1,068 | [illegible] |
| 189 | E. M. Cooley | Sec. 27, T. 1 S., R. 4 W. | 1,019 | 959 | 977 | +18 |
| 199 | Washington School | do | 1,043 | 966 | 961 | -5 |
| 201 | Fred Pooles | Sec. 33, T. 1 S., R. 4 W. | 955 | 907 | 895 | -12 |
| 277 | G. Renwick | Sec. 8, T. 1 S., R. 4 W. | 1,090 | 1,055 | 1,050 | [illegible] |
| 280 | E. Memory | Sec. 20, T. 1 S., R. 4 W. | 982 | 927 | 920 | [illegible] |
| 282 | C. H. Westmyer | Sec. 8, T. 1 S., R. 4 W. | 1,069 | 1,062 | 1,048 | -14 |
| 316 | Geo. M. Cooley | Sec. 36, T 1 N., R. 4 W. | 1,150 | 1,108 | 1,090 | -18 |
| 317 | do | do | 1,150 | 1,108 | 1,090 | -18 |
| 317a | do | do | 1,150 | 1,108 | 1,090 | -18 |
| 318 | E. J. Stiles | Sec. 35, T. 1 N., R. 4 W. | 1,196 | 1,157 | 1,146 | -11 |
| 319 | Jas. Dickson | do | 1,179 | 1,145 | 1,131 | -14 |
| 329 | Muscupiabe Land and Water Co. | Sec. 23, T. 1 N., R. 4 W. | 1,288 | 1,143 | 1,115 | [illegible] |
| 341 | H. N. Stones | Sec. 34, T. 1 N., R. 4 W. | 1,141 | 1,087 | 1,078 | [illegible] |
| 354 | S. F. Kelley | Sec. 28, T. 1 N., R. 4 W. | 1,170 | 1,121 | 1,095 | -26 |
| 357 | S. H. Johnson | do | 1,182 | 1,122 | 1,082 | -40 |
| 364 | F. Alvarado | Sec. 32, T. 1 N., R. 4 W. | 1,188 | 1,135 | 1,118 | -17 |
| 367 | D. W. White | Sec. 4, T. 1 S., R. 4 W. | 1,109 | 1,089 | 1,074 | [illegible] |
| 370 | F. L. Holcomb | Sec. 33, T. 1 N., R. 4 W. | 1,128 | 1,100 | 1,078 | -22 |
| 375 | Dexter Field | Sec. 5, T. 1 S., R. 4 W. | 1,147 | 1,112 | 1,089 | -23 |
| 389 | S. E. A. Palmer | Sec. 33, T. 1 N., R. 4 W. | 1,176 | 1,124 | 1,099 | -25 |
| 398 | N. M. Swarthout | do | 1,142 | 1,115 | 1,094 | -21 |
| 400 | J. H. Lytle | do | 1,166 | 1,135 | 1,086 | -49 |
| 416 | H. H. Ham | Sec. 34, T 1 N., R. 4 W. | 1,121 | 1,090 | 1,075 | -15 |
| 445 | A. W. Bemis | Sec. 5, T. 1 S., R. 4 W. | 1,114 | 1,104 | 1,077 | -27 |
| 450 | M. D. Reynolds | do | 1,116 | 1,094 | 1,076 | -18 |
| 457 | J. F. Cadd | Sec. 4, T. 1 S., R. 4 W. | 1,068 | 1,057 | 1,052 | -5 |
| 458 | H. E. Gardner | Sec. 5, T. 1 S., R. 4 W. | 1,089 | 1,079 | 1,063 | -16 |
| 470 | Charles Morris | Sec. 26, T. 1 S., R. 4 W. | 1,078 | 1,063 | 1,054 | -9 |

At one point within the valley systematic measurements of the water level have been continued through a term of years. For these measurements we are indebted to the Gage Canal Company, its enlightened management, and its able engineers. The "Williams" well, in which these measurements have been made, is near the east end of the Victoria tract, and on the south side of Santa Ana River. In 1892 and in the spring of 1893 this was a flowing well. It has not flowed since, but each year it has declined, until in June, 1904 the water level was 38 feet below the surface (fig. 12).

During the three years preceding 1898 the measurements were made only at long intervals and the details of the decline were not determined. Since that date measurements have been made frequently, and it is found that while the average condition is one of decline, this is at a varying rate, and is interrupted by periods of rise, so that a profile of the attitude of the water plane, with months used as the time units and feet as the units of elevation, exhibits a series of pulsations, the water level rising each spring in consequence of the winter rainfall and declining from that time until after the beginning of the next rainy season. These upward movements were especially marked during the springs of 1901 and 1903, the rainfall at San Bernardino in the preceding winters having been heavier than the average for thirty-four years. Between the 1st of October, 1900, and the 1st of April, 1901, the water level rose nearly 9 feet, and a rise of 8 feet is shown between February 1 and June 1, 1903, but the crest of the 1903 rise was 10 feet lower than that of the spring two years before, showing clearly the marked general lowering.

Again, a curve showing the average decline since observations began is markedly steeper during the period from 1896 to 1900 than before or since, thus indicating that, however many causes have been operative in producing the effect observed, the diminished rainfall during those dry years was a most potent factor. The situation of this well near Santa Ana River results in prompt responsiveness to periods of heavy precipitation or of drought, and accounts for the strongly marked annual fluctuations in water level, which are not observed in wells at greater distances from important waterways. In the latter cases the percolation of the flood waters for long distances through sand and gravel smooths out the waves and reduces them to an average.

Mr. Gudeman Johnson, north of San Bernardino, has kept a record of the water level in his well for some years past, and while there are some long intervals in it during which no measurements were made, it is sufficiently full to show the absence of such marked annual pulsations as are characteristic of the Williams record. Yet its general results are identical: It shows a decline of 27 feet from June, 1899, to June, 1904, a lowering of the plane of saturation of more than

5 feet a year. It likewise shows a markedly steeper gradient for the dry period preceding 1901 than for the four seasons following, during two of which, 1900–1901 and 1902–3, the precipitation at San Bernardino has been above the average of the last thirty-four years, although, since the deficiency during 1901–2 and 1903–4 was greater than the excess for the other two winters of the four, the final result is a deficiency for the period of more than 5 inches (fig. 13).

Although outside San Bernardino Valley and influenced somewhat by local conditions, a profile of the water plane at Anaheim, Cal., as determined by Mr. J. B. Neff, is here introduced for comparison (fig. 14), and for general confirmation of the effect observed in the case of the interior wells. The total decline of the water level in

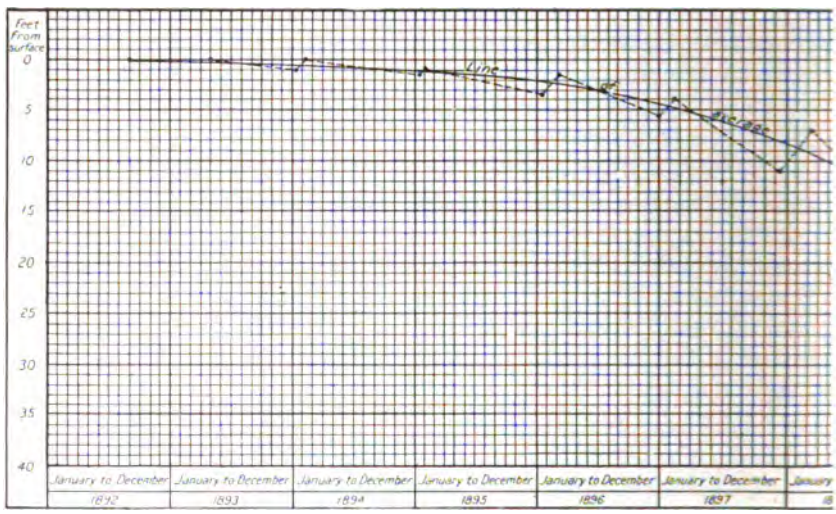


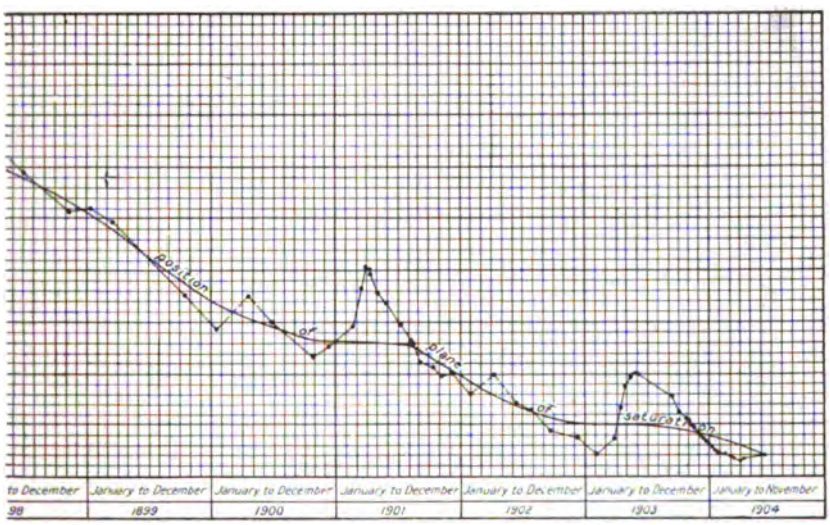

FIG. 12.—Chart showing variatio

this well from the beginning of observations in February, 1898, to January 1, 1905, is 27 feet 8 inches. In this well also the lowering of the water level was much more rapid during the years preceding the winter of 1900–1901 than since. In it also there is a definite rise of the water plane during the early months of 1901 and 1903, although this rise is of smaller magnitude than in the case of the Williams well.

The significant thing about all of these profiles is that the gain effected during the winters of slight excess was in each instance lost before the end of the succeeding dry season. Only two doubtful points can be selected in the Williams profile in which the ground-water level is higher than at a corresponding time during the previous year. These two points are the crests of the floods of 1901 and 1903, and in every case the lowest point of any particular year is lower than the lowest point of the preceding year. This is true of the years

1900–1901 and 1902–3, during which the rainfall was 2 inches above the average. The loss in these cases was small, but distinct.

In Mr. Neff's well, at Anaheim, where the pulsations are distinctly less in magnitude, the loss between June 1, 1903, and June 1, 1904, was 2 inches, and between November 4, 1900, and November 8, 1901, 3 inches. These dates are the most favorable that can be selected, and each pair spans a year during which the rainfall exceeded the average by about 2 inches, or over 13 per cent. Years of more than average precipitation, then, have very decidedly checked the rate of decline of the ground waters, but have not brought about a cessation of that decline. The average precipitation will be even less efficient, and if maintained through a term of years during which




of water level in the Williams well.

there should be no change in the amount drawn from the basin, the surface of the stored subterranean waters would inevitably continue to fall, although, of course, at a less alarming rate than during the period preceding the winter of 1900–1901.

It is not possible with the data at hand to predict the effect of a series of wet years like the decade from 1883 to 1893, but such a prolonged wet period is not likely to occur again within a generation. A scrutiny of the available records shows that it has not been duplicated in a half century.

A very large percentage of a moderate precipitation evaporates at once or is required to moisten the surface soil. The proportion which as run-off becomes available for recharging the subterranean reservoirs increases at a rapidly accelerating rate as rainfall increases. At the same time less irrigation is necessary during winters of heavy

rainfall, and a large proportion of the reduced irrigation is accomplished by surface waters, the streams during such seasons flowing near their maximum. Hence, at such a time, drafts upon the underground supplies are diminished and additions to them are increased, resulting in a rapid improvement of conditions. Our profiles of water levels, however, indicate that such improvements will not be permanently effective in the San Bernardino basin unless the rainfall is in excess of 17½ inches, and records indicate that only one year in three exhibits such an excess.

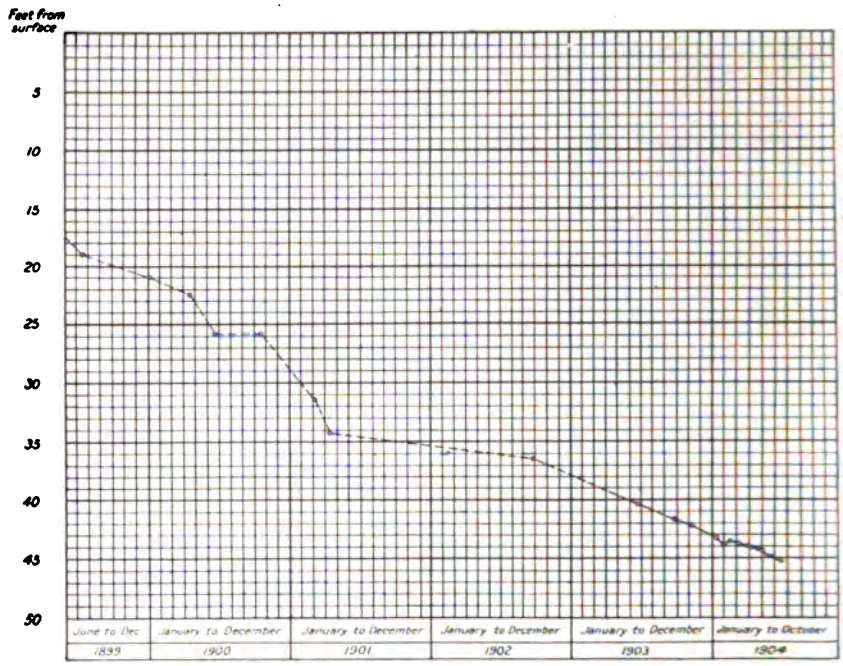



FIG. 13.—Chart showing variation of water level in the Johnson well, near San Bernardino.

Accompanying this decline of the ground waters there has been a definite decrease in the extent of the artesian basin. The San Bernardino basin was probably about at its maximum late in the eighties. At that time its area was approximately 30 square miles. In 1900, after the three especially dry winters of 1898, 1899, and 1900, it had shrunk to approximately 15.3 square miles, and at the beginning of 1904 there had been a further slight shrinkage to 14 square miles (Pl. VII).

A phenomenon which expresses the same condition as the falling water plane and the decreasing artesian area is that of decreasing pressure within the artesian belt. This results in a falling off in artesian flow and a lessening of the yield from springs which rise in the moist lands. The following table, in which the amounts of natural

rising waters and of developed waters within the basin during the last six years are shown, indicates the character of this change.

FIG. 14.—Chart showing variation of water level in the Neff well, near Anaheim.

*Comparison by years of flowing water and developed water above Colton, Cal.*

[Kingsbury Sanborn, observer.]

| Date. | Flowing water. | Developed water. | Total. |
|---|---|---|---|
| | *Second-feet.* | *Second-feet.* | *Second-feet.* |
| September, 1898 | 78.31 | 66.38 | 144.69 |
| August, 1899 | 44.68 | 65.46 | 110.14 |
| September, 1900 | 54.18 | 71.42 | 125.60 |
| September, 1902 | 38.52 | 81.69 | 120.21 |
| August and September, 1903 | 45.55 | 109.70 | 155.25 |
| August, 1904 | 38.62 | 105.36 | 143.98 |

The measurements indicate an irregular but none the less marked decrease in the natural flowing waters accompanying an equally marked increase in the quantity of developed waters. The latter has been made necessary in order that the total supply might be kept up. The causes of these shrinkages, which have been thus set forth in some detail, are twofold—the decreased rainfall of the last decade, and the increased development of waters during the same and a preceding period.

The average rainfall at San Bernardino during the last thirty-four years, which may be accepted as typical of the upper valley, has been 15.06 inches. This should be within 2 per cent of the final correct average rainfall for that point. While on the southern slopes and summits of the San Bernardino Mountains the precipitation has been heavier, and in parts of the lowlands more remote from the mountains it has been lighter, the percentages of variation from the normal at any selected point may be safely assumed to be approximately equal to that at San Bernardino. Here, while the general average is 15.06 inches, the average for the last eleven years is 12.14 inches, giving a total deficiency of over 32 inches for that period, and for the last seven years the average has been but 11.36 inches a year. Such a deficiency in a region where all the normal run-off is appropriated at the canyon mouths and only the excess is set free to recharge the gravels that form the underground reservoirs means a proportionately very large reduction in the latter element. And necessarily during years of drought the drain upon the underground supply is greater than during years of normal or excessive rainfall, because during the latter periods several of the winter irrigations may sometimes be omitted, the flowing wells capped, and the pumping plants shut down for a time. Hence, in addition to the decreased supply there have been increased demands on the underground waters during the last ten years, demands independent of the gradual increase in water required by increasing acreage and the greater maturity of groves.

Enterprises like the Bear Valley dam and the suggested reservoir at Filirea Flat, on the upper Santa Ana, although most economical when the region as a whole is considered, necessarily reduce the amount of water available for recharging the gravels below them and thus act unfavorably upon the districts dependent upon the supply in these gravels for irrigation. These dams retain practically all the water which falls above them in their respective drainage basins, so that this supply, instead of escaping during the winter, to be absorbed in large part by the gravels, is stored and used for irrigation, and the underground reservoirs receive only the uncertain amount of return waters from the groves.

In addition to these reductions in the supply through decreased rainfall and developments at the headwaters, there have been many additional wells sunk within the basin for domestic supplies for the growing tributary cities; by the old established companies to maintain the supply necessary to preserve the acreage served by them and to make up for the loss through the shrinkage of surface streams like Warm Creek and the Santa Ana, at one time a prolific source of irrigation water; and by new companies for the reclamation of new tracts.

An attempt to estimate the amount of water which may be taken from the basin without drawing upon the reserve supply is fraught

with difficulties. The amount of water stored in the gravels of the valley is undoubtedly very great. Mr. Lippincott[a] has estimated roughly that their capacity is 6,400,000 acre-feet, an estimate which unquestionably is sufficiently low. This amount, if it could be made available, would supply the canals above Colton for sixty years without the annual additions from rainfall.

As a matter of fact, but a small proportion of it is commercially available. These saturated gravels have been penetrated to depths of over 1,000 feet, and it is estimated that in the center of the valley they may exist at 3,000 feet below the surface. The depth from which water can be pumped at a profit depends upon the value of the crops raised by its use and upon the cost of its distribution. The maximum at present may be accepted as 250 feet, and at this depth certainly less than 20 per cent of the stored waters of the valley could be reached. It is obvious, however, that this water should not be taken out any faster than it is annually restored. The rate of this recharge is a difficult problem.

No definite results can be reached by an attempt to estimate the amount of water which is directly contributed to the basin, since the amounts supplied by rainfall within the valley, or by floods from the mountains, or by seepage through the gravels below the measured surface flows of tributary streams, or by the minor unmeasured canyons about the margin of the basin, or by return waters from irrigated lands which drain back into the valley, must all remain undetermined factors.

By approaching the subject in another way, however, suggestions which appear to be of value result. The Williams and the Neff measurements upon the water plane have already been discussed in part. In each of these the gradient of the decline in water level flattens during the years 1900–1 and 1902–3, until it becomes nearly horizontal. The rainfall during each of these years was more than 17 inches at San Bernardino, where the normal is about 15 inches. If we accept the probable assumption that 2½ inches more than the normal rainfall would check the decline under present conditions of development, and that it might also be checked by reducing the drafts upon the basin by the same percentage, we arrive at the conclusion that about 115 second-feet may be withdrawn without permanently reducing the reserve supply.

Some steps have been taken by the greater irrigating companies, which are dependent upon the underground supplies of San Bernardino Valley, to check the escape of the floods that pass the Bunker Hill dike, in order that more time may be given for their absorption by the porous sand and gravel filling of the basin. Thus far

[a] Lippincott, J. B., Development and application of water near San Bernardino, Cal.: Water-Sup. and Irr. Paper No. 59, U. S. Geol. Survey, 1902, p. 23.

these efforts have been confined to the construction of a number of low sand ridges across the Santa Ana wash. They check the minor floods for a time and are considered of value by those who have planned them.

More elaborate systems for distributing flood waters over wider areas of fan material, so as to secure a much greater absorption of floods than is brought about by these temporary structures, have been suggested and may eventually be definitely planned and carried out. The control of the great floods, with their heavy load of débris and their high velocity, offers especial engineering difficulties and may never be undertaken, but it is thought that smaller floods, the larger part of which are wasted, may be so distributed as to greatly increase the proportion which at present sinks.

Failure or decrease in output are familiar conditions in artesian districts. The causes are manifold and vary with the region. One of the most familiar examples is that of the Denver basin,[a] discovered in 1884. In a few years 400 wells had been drilled in that district, and many of them gave strong flows under good pressure. By the end of 1890 nearly all had ceased to flow and many were permanently abandoned. The explanation given for the failure in this case was the low porosity and transmission capacity of the water-bearing rock. The water which flowed when the wells were first sunk had accumulated by very slow percolation through long periods. When this supply was withdrawn the fine grain of the transmitting rock prevented a renewal sufficiently rapid to keep up the pressure.

Other cases exist where the failure of a particular well is due not to general conditions within the district, but to faulty construction of the well itself, or to filling by sand or débris from below or above, or, as in the case of the wells at Savannah, Ga.,[b] to a slow sealing of the pores in the water-bearing stratum by gelatinous deposits or microscopic plant growth. The failure of an individual well, when not due to some general cause which affects the artesian supply as a whole, will not be accompanied by the failure of neighboring wells, and if another well is sunk in the vicinity its flow in this case will be as great as that of the original well.

The high porosity, the coarse grain, and the unconsolidated character of the gravels of San Bernardino Valley preclude the possibility of failure due to the causes which were effective at Denver. Local diminution of flow often results from the clogging of small-bore wells, and the accumulation of sand and gravel at the bottom of a well, with a consequent falling off in the yield, is testified to by a lessened depth as determined by sounding. The majority of the failures

[a] Eldridge, G. H., Artesian wells, in Geology of the Denver basin in Colorado: Mon. U. S. Geol. Survey, vol. 27, 1896, p. 428.

[b] Slichter, C. S., Motions of underground waters: Water-Sup. and Irr. Paper No. 67, U. S. Geol. Survey, 1902, p. 94.

however, are clearly general in their character and affect whole groups, particularly those of moderate depth and those near the eastern and northern borders of the basin. These results are due to a gradual reduction of head through a drawing down of the supply.

The general conclusions to be drawn from the foregoing discussion may be summarized thus:

(*a*) The shrinkage of the artesian area, the lessened yield of artesian wells, and the lowering of the ground-water level outside the artesian boundary are marked.

(*b*) The rapid rate of this shrinkage is due to the combination of continuous development and decreased rainfall. Either acting alone would produce similar but less pronounced results.

(*c*) Average rainfall, while the present drafts upon the underground waters within the basin continue, will not restore the original water level, but will permit the waters to decline gradually.

(*d*) Rainfall of at least 17½ inches at San Bernardino, with a proportional precipitation over the drainage basin of the upper Santa Ana, is required to check the declines while drafts continue at the present rate. Records indicate that on the average this amount of rain may be expected one year in three.

(*e*). A long wet winter may restore the declines of several seasons of average rainfall or less, but since declines must be expected during at least two seasons in three it is obviously unwise to increase present drafts upon the basin.

(*f*) Strict economy in the use of water, improvements in irrigation practice, and a definite and fully supported policy of forest conservation and restoration are essential to the well-being of this valley. It is believed that much may be done also to improve conditions in the underground reservoirs by the construction of dams to check floods and distribute them over broader areas, to the end that they may be more fully absorbed. So far as the writer is aware this last means of preventing waste was first suggested by Prof. E. W. Hilgard in 1902.[a] Recently it has been given renewed attention by engineers of southern California and tentative steps toward it have been taken by the Riverside companies, which, for at least two winters past, have checked and distributed the Santa Ana floods with gratifying results.

## OTHER ARTESIAN AREAS.

### YUCAIPE BASIN.

On the Dunlap ranch in the Yucaipe Valley a number of artesian wells, varying from moderate depths to over 800 feet, were drilled between 1895 and 1900. The water secured has been piped to Red-

[a] Subterranean water supply of the San Bernardino Valley: Rept. of irrigation investigations for 1901, Bull. U. S. Dept. of Agric., No. 119, 1902, pp. 133-134. The subject has also been discussed by Mr. F. E. Trask, in an essay published in the Rural California, June, 1903, entitled "Water Conservation in Southern California."

lands and forms an important part of the supply there. This interesting group taps a water supply in the earlier alluvium, a source entirely different from that in which the water at San Bernardino is found. The beds of this older alluvium form the Yucaipe bench, make the hills on either side of San Timoteo Canyon, and extend eastward beyond the area under consideration toward San Gorgonio Pass (fig. 15 and Pl. IX). South of Yucaipe Valley they dip gently northward, the dip increasing in steepness toward the axis of the Badlands ridge which separates San Timoteo Canyon from San Jacinto Valley (fig. 15). This attitude of the beds is due to crustal movements since their deposition. North and east of the Yucaipe they lie horizontal or have slight south and west dips, which may not be structural but only representative of the original depositional slope.

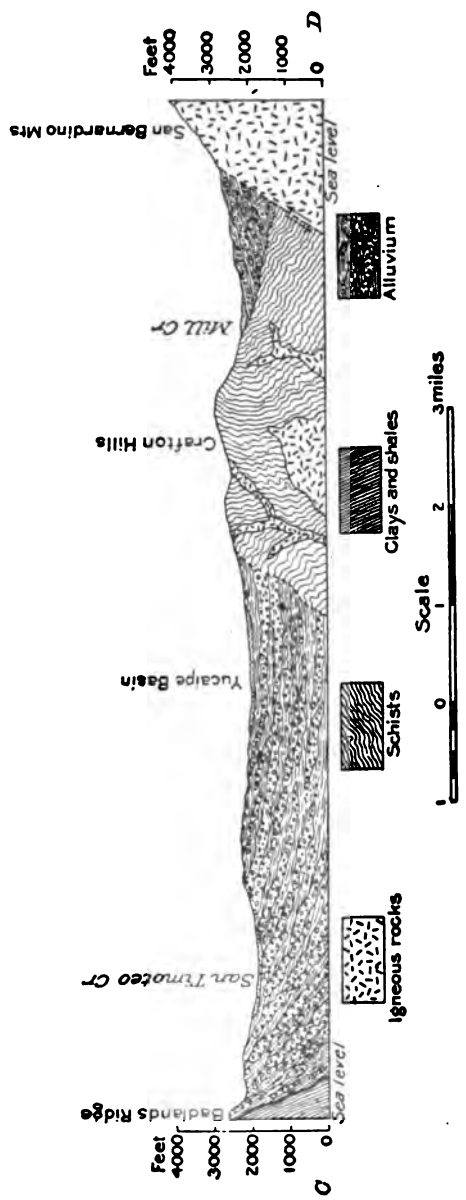



FIG. 15.—Approximate section across the Crafton Hills and Yucaipe Valley along the line C–D, Pl. XII.

The Crafton Hills and the heights on either side of Reservoir Street Canyon are of schistose or igneous bed rock. These two areas are undoubtedly connected, although the connection is buried under alluvium through the lower intervening region. It is probable, too, that the pass between the Crafton Hills and the mountains just east of Mill Creek Canyon is underlain at a moderate depth by bed rock, so that the Crafton Hills mass makes, as it were, a wing dam extending southwest some miles from the San Bernardino Mountains into the alluvial areas. All the streams draining south and west from the hills that separate Mill Creek from the wide valley to the south sink into this old alluvium and percolate slowly through it toward the lower levels.

VIEW OF SAN TIMOTEO CANYON AND THE NORTHWARD-DIPPING EARLIER ALLUVIUM.

They are checked by the Crafton bed-rock mass, and in the vicinity of the mouth of Liveoak Canyon or above meet the northward dips of the alluvium. In the basin thus formed the waters collect under pressure and flow when the porous gravels are tapped by wells. The ordinary overflow from this basin must percolate around the southwestern foot of the Redlands Heights bed-rock area, since its lowest outlet lies in this direction. In the past, after long-continued periods of excessive rainfall, when the Yucaipe gravels had become saturated to higher levels than at present, the canyon through which lies the continuation of Reservoir street toward Yucaipe Valley probably became a spillway. Springs and small areas of peaty land near the head of the canyon are evidences for this hypothesis.

In lower Yucaipe Canyon, a mile or two above its junction with San Timoteo Creek, waters under pressure have been found at depths of several hundred feet. They rise practically to the surface, but do not flow, or flow but little. These waters and those tapped by the Singleton wells in San Timoteo Canyon, as well as those which are the sources of springs in the short northern tributaries of the latter, are probably all supplied from the underground waters gathered in the drainage basin of the upper San Timoteo and its tributaries and percolating along the lines of least resistance toward Santa Ana River. The Crafton Hills bed-rock obstruction and the northern dip of the alluvium south of this obstruction must tend to concentrate the waters in the pervious strata in a relatively narrow zone extending from a short distance south of Bicknell station, on the Southern Pacific, to the vicinity of Redlands Heights. The Redlands wells near the reservoir, and the Redlands Heights wells farther south, are regarded as tapping the principal underground outlet for the drainage area east of Crafton Hills and west of Beaumont. As this area is not large and the precipitation, except on that very small portion of it which forms a part of the slope of the San Bernardino Range, is slight, the waters can not exist in great volume, and so will not bear excessive development. Thus far they seem to have been drawn upon moderately and with excellent judgment.

As has been stated before, the gravels of the earlier alluvium are partially consolidated. They seem, on the whole, to be less pervious than those of later date, and are therefore somewhat inferior in transmission capacity. Because of these two conditions—limited supply and low transmission power—no wells of very great yield have been opened and none are to be expected.

The favorable area for development has been pretty well outlined by the wells which have been bored. It includes the flat valley of the Yucaipe in the vicinity of Dunlaps (Pl. X, *A*), and the area south of it to the Southern Pacific at El Casco and for a short distance above. Westward it extends to beyond Redlands Heights, which it underlies. Within this area it is expected that wherever porous gravels are

encountered by the drill a fair supply of water will be found. The deeper waters are under pressure, and where the well is started at a low point, as in the bottom of one of the deep arroyos, water may rise nearly to the surface. In wells which are begun on high ground a heavy lift will be necessary. While porous water-bearing gravels are usually found in the well sections, they are less numerous and less certain than in the newer gravels of the valley about San Bernardino. Furthermore, the irregular character of all of this alluvial material precludes the possibility of predicting accurately where coarse gravels are present and where not. Only exploration by the drill can determine this point.

### RIVERSIDE BASIN.

Just north of Riverside, in the basin of Spring Brook, four wells have been drilled which yield flowing water, and the springs by which the small stream is fed indicate the probable extension of artesian conditions beyond the area determined by the wells.

A mile or more above the Salt Lake Bridge at Riverside Narrows is a small flowing well which furnishes water for domestic purposes, and other artesian wells now filled, or abandoned for other reasons, are reported from the same vicinity.

At Riverside Narrows Santa Ana River enters a narrow gorge cut in the dioritic bed rock of the region, and the underground waters are forced to or near the surface as they approach this obstruction. In consequence, the river bed, dry for some miles below Slover Mountain, here carries a perennial stream of respectable proportions. The effect of this diorite mass is similar to that produced by the ridge of folded clays which crosses the course of the Santa Ana above Colton and has been discussed as the Bunker Hill dike.

The river wash which has accumulated against the mass is saturated, it contains coarser and finer material in alternating strata, and as these, deposited by the river, slope in the direction of its flow, water entering the coarser members at a higher level farther up the stream is to be found under pressure at a lower level farther down the stream. The waters of the Elliotta, Stansell, and Evans wells above Riverside probably enter the gravels soon after they have passed over the Bunker Hill fold, and their head is only that which accumulates in the few intervening miles. There is little doubt that the water percolates under the High Grove and East Riverside mesas, which are underlain by river alluvium, deposited at a time when the Santa Ana or one of its distributaries flowed through this lowland.

These gravels about Riverside are not generally as coarse as those above the Bunker Hill dike, since they are farther from their origin in the mountains; hence they are somewhat less free water bearers, although excellent in this respect. Flood waters have access to them

*A*. YUCAIPE VALLEY AND ARTESIAN LANDS.

*B*. NONARTESIAN WATER-BEARING LANDS IN SANTA ANA VALLEY.

chiefly through the porous wash of the river below Bunker Hill, while the basin above is supplied by the waters absorbed by all of the alluvial fans distributed along the base of the San Bernardino Range.

The Riverside basin is shallower and has a smaller area than the large basin northeast of it, but it has not yet been very heavily drawn upon, and it is benefited by the return waters from a large acreage about Rialto and East Riverside. It should be capable of supplying much larger drafts than have as yet been made upon it, and although the waters thus developed will have to be pumped to the accessible lands, and so will prove more expensive than San Bernardino basin waters now are, the difference in cost may be expected to lessen as the latter waters become more expensive, so that it may soon become financially practicable for the Riverside irrigator to utilize more of these near-by waters and thus reduce the great drafts upon the larger and more important San Bernardino basin.

The city of Riverside is now (1904) installing a domestic system which will utilize a part of these waters. They are to be pumped to a reservoir on Rubidoux Hill and distributed thence to the city mains. Thus used they will augment the supply that now flows by gravity from artesian wells in the San Bernardino basin.

## GROUND WATERS.

By ground waters are meant subsurface waters outside the artesian areas (Pls. VII and VIII), which therefore are not found under sufficient pressure to flow by gravity, but become available for irrigation only by means of some sort of pumping device. They have precisely the same origin as the artesian waters—i. e., the rainfall—and, indeed, when they lie above the artesian basin, may later become artesian by passing beneath an impervious cap in the course of their slow movement seaward under the influence of gravity. Below and outside of the basin they constitute the normal subsurface zone of saturation, whose upper limit slopes generally with the soil surface, but at a different rate, so that where the fan material lies high and is open textured it may be hundreds of feet to the ground-water level. This is probably true in the vicinity of Grapeland and some miles southward. Nearer the axis of the valley these waters are nearer the surface and are drawn upon more or less freely for irrigation and for domestic purposes. Their approximate position relative to the surface, where data enough exist for determination, is shown on Pl. VII for the years 1900 and 1904.

West of Lytle Creek the water lies at so low a level and the wells are so few that no attempt has been made to show the position of the water plane, data being entirely insuffiicient for this purpose.

From a point a mile or more below Crafton eastward the water level seems to have changed but little during the last few years. In a zone immediately surrounding the artesian basin, however, there has been

a distinct change in the water level, a decline varying in amount from zero at the edge of the artesian area to 50 feet in extreme cases some distance back.

On pages 57 and 58 are given tables in which the elevation of the water plane at two periods, four years apart, is shown for a number of wells distributed widely over San Bernardino Valley.

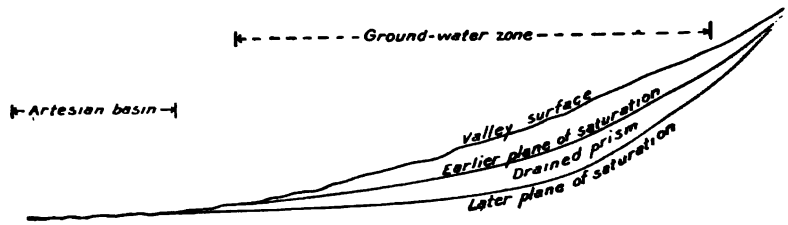



FIG. 16.—Diagrammatic cross section of drained prism in alluvial-fan material.

It is to be noted that the earlier and the present elevations of the water plane are approximately equal at both the upper and the lower edges of the ground-water zone—i. e., the past and the present planes of saturation unite near the artesian limit and again well up the alluvial fans, their most marked divergence being along a median line of the zone, a cross section of the drained prism being thus crescentic in form (fig. 16).

## TEMPERATURES.

Waters with temperatures much above the normal are not at all unusual in San Bernardino Valley, nor in other parts of southern California. The region in general is not one of recent volcanic activity, so that, in the majority of cases at least, we have no bodies of fresh intrusive or effusive rock to appeal to as a source of heat. On the other hand, there have been abundant recent dynamic disturbances, as is proved clearly on structural grounds, and the slight earthquakes which occur from time to time suggest that minor movements may be taking place almost constantly along the established fault lines. The enormous friction from these movements must raise the earth temperatures very notably along the lines of disturbance, and the fractured zones adjacent to the faults must sometimes provide easy channels through which surface waters may reach greater depths, become heated, and rise again as hot springs, or through which rock waters with the temperatures of their origin may escape to the surface.

If we consider the distribution of the hot springs we find that, with a few unimportant exceptions, they occur along these definite structural lines, or if we reverse the process and trace the major fault lines we find them marked in many instances by thermal waters.

The most extensive and important group of hot springs is that which issues from crevices in the gneissoid bed rock at the south base of the San Bernardino Range in the vicinity of East Twin Creek Canyon.

THE BUNKER HILL DIKE.

The easternmost group of these is known as the Arrowhead Springs, from the peculiar figure of a gigantic arrow outlined by the vegetation on the mountain side above them. Numerous springs issue here at various temperatures, the highest measured by the writer being 184° F. One-half mile farther west an even greater volume of hot water, estimated at 5 or 10 miner's inches, issues from a number of springs that flow usually from the bowldery alluvium along the lower course of Waterman Canyon (West Twin Creek), but occasionally directly from bed rock. Much of this water has a temperature of 140° or 150°, and even higher as it first issues. A small group of warm springs is found about a mile east of Arrowhead Peak, and in the canyon of the Santa Ana, 2 miles from the edge of the mountains, is another conspicuous warm spring.

The line of disturbance whose western extension is marked by the Bunker Hill fold (Pl. XI) is even more definitely outlined by a series of wells and springs with temperatures above the normal. Within the San Bernardino basin itself a temperature of 72° is found in the mixed waters from three wells pumped into one distributing pipe near the San Bernardino city reservoir. Another well whose waters have a temperature of 90° has been bored about a mile northwest of Bunker Hill and just north of the dike. The latter location is one in which numerous wells of abnormal temperature are found. The "Hobo" well, the Urbita well, and the Topp well, all near Bunker Hill, have temperatures varying from 85° to 105°. Farther eastward a group of shallow wells belonging to the Riverside Water Company, and distributed along the north bank of Santa Ana River, just east of E street extended, have temperatures of 71° to 73°, although less than 100 feet deep in many instances.

Near Loma Linda a number of wells of the Gage canal system discharge waters at temperatures of 70° to 75°, but in these cases the depths are greater, ranging from 320 to 656 feet. Farther east and entirely outside the territory under discussion in this paper, but worthy of mention here because they occur along the same structural line, are the Eden, the Relief, and the Ritchie hot springs, which issue from bed rock near the zone of structural weakness.

This distribution is in itself strong evidence that the heat which is imparted to the underground waters originates, in many cases at least, in the zones of crustal movement, especially the faults, which are a conspicuous feature of the geology of southern California.

Within the San Bernardino Valley lowland, temperatures, except as they are high along the line of the Bunker Hill dike, have a rather erratic distribution. The mean annual atmospheric temperature of the valley is about 62° F., and the ground waters and the waters from the majority of the shallow flowing wells have the normal temperature of 62° to 64°; but at Harlem Springs waters originally issued at vari-

ous temperatures up to 115°. The flowing waters of the Payne well, 642 feet deep, situated 2 miles south of San Bernardino, have a temperature of 112°. The water of the Urbita Springs well has a temperature of 102° to 105°, and other wells which have been mentioned near the Bunker Hill dike exhibit temperatures ranging from 70° to 90°.

When we come to consider temperature gradients—i. e., the number of feet it is necessary to go in depth for each degree rise in temperature from the normal of 62° or 63°—we find such wide extremes as 1° in 3 feet in the "Hobo" well, No. 23, San Bernardino quadrangle, and 1° in 114 feet in one of the Riverside Water Company's deep wells on East Third street. The accompanying table of depths and temperatures illustrates the wide diversity, both in temperatures and in temperature gradients, throughout the valley.

*Temperatures in wells in San Bernardino Valley, California.*

| Number of well. | Depth of well. | Measured temperature at surface. | Theoretical temperature on basis of 1° increase for each 60 feet depth. | Departure from theoretical temperature. | Temperature gradient. |
|---|---|---|---|---|---|
| | *Feet.* | °*F.* | °*F.* | °*F.* | *Feet.* |
| 53 | 68 | 71 | 63 | + 8 | [illegible] |
| R 361 | 68 | 86 | 63 | +23 | [illegible] |
| 17 | 81 | 73 | 63 | +10 | [illegible] |
| 252 | 83 | 68 | 63 | + 5 | 16 |
| 18 | 92 | 73 | 64 | + 9 | [illegible] |
| 23 | 121 | 98 | 64 | +34 | [illegible] |
| 8 | 125 | 68 | 64 | + 4 | 2[illegible] |
| 125 | 141 | 67 | 64 | + 3 | 2[illegible] |
| 123 | 142 | 70 | 64 | + 6 | 1[illegible] |
| 124 | 148 | 68.5 | 64 | + 4.5 | 2[illegible] |
| R 330 | 150 | 68 | 65 | + 3 | 2[illegible] |
| 234 | 158 | 85 | 65 | +20 | [illegible] |
| 328 | 169 | 76 | 65 | +11 | 1[illegible] |
| 126 | 181 | 68 | 65 | + 3 | 3[illegible] |
| R 327 | 185 | 80 | 65 | +15 | 1[illegible] |
| 122 | 190 | 70 | 65 | + 5 | 2[illegible] |
| 121 | 196 | 70 | 65 | + 5 | 2[illegible] |
| 19 | 225 | 71 | 66 | + 5 | 2[illegible] |
| R 329 | 231 | 72 | 66 | + 6 | 2[illegible] |
| R 385 | 300 | 115 | 67 | +48 | [illegible] |
| 119 | 320 | 73 | 67 | + 6 | [illegible] |
| 297 | 451 | 90 | 70 | +20 | [illegible] |
| R 375 | 460 | 72 | 70 | + 2 | [illegible] |
| 128 | 472 | 70 | 70 | 0 | [illegible] |
| 118 | 482 | 74 | 70 | + 4 | [illegible] |
| 104 | 506 | 70 | 70 | 0 | 6[illegible] |

*Temperatures in wells in San Bernardino Valley, California*—Continued.

| Number of well. | Depth of well. | Measured temperature at surface. | Theoretical temperature on basis of 1° increase for each 60 feet depth. | Departure from theoretical temperature. | Temperature gradient. |
|---|---|---|---|---|---|
| | *Feet.* | °*F.* | °*F.* | °*F.* | *Feet.* |
| 106 | 517 | 73 | 71 | + 2 | 47 |
| 116 | 534 | 74 | 71 | + 3 | 44 |
| 465 | 544 | 68 | 71 | − 3 | 91 |
| 117 | 582 | 74 | 72 | + 2 | 49 |
| San Bernardino city well on Antill tract | 614 | 69 | 72 | − 3 | 88 |
| 112 | 642 | 112 | 73 | +39 | 16 |
| 115 | 656 | 75 | 73 | + 2 | 50 |
| 315 | 682 | 68 | 73 | − 5 | 114 |
| Urbita new well | 740 | 78 | 74 | + 4 | 46 |
| 120 | 784 | 74 | 75 | − 1 | 65 |
| Waterman avenue well, Riverside Water Co | 984 | 75 | 78 | − 3 | 76 |

The results can not be accepted rigidly, because in some cases well tubing has been cut at several points and the waters whose temperature is given are therefore mixed waters from undetermined horizons. In one or two other cases the yield of the wells is small, the waters rise but slowly, and sensible changes may therefore have taken place in their passage upward to the surface where the temperatures were measured. But when due allowance is made for these inaccuracies a wide variation remains to be accounted for.

The alternate undisturbed beds of sand, gravel, and clay which fill this valley should exhibit a thermometric gradient which is lower rather than higher than the normal of 1 degree for each 50 or 60 feet increase in depth, which has been established by observations in shafts and deep mines in consolidated rock in various parts of the world. A lower gradient is to be expected, because this alluvium has been deposited recently and with great rapidity, and so may be supposed not to have acquired fully the normal earth temperature. An additional reason for expecting low temperatures is its porosity and the consequent free circulation of meteoric waters, which tend to carry the mean annual temperature of the surface to depths. The low gradients exhibited by the new Antill tract wells of the city of San Bernardino and by the Riverside Water Company's wells Nos. 465 and 315, gradients of 88 to 114 feet per degree, seem to bear out this hypothesis of relatively low temperatures at moderate depths, due to lag in the rise of earth temperatures or to transfer of surface temperatures to depth through the medium of circulating waters. Such low temperatures are to be expected under the conditions which prevail in this basin, but

where higher temperatures are found special explanations seem to be required.

Along the line of the Bunker Hill disturbance the occurrence of high temperatures is fully explained by the known geologic conditions. This ridge represents an anticlinal arch, the strata, which farther north occur at greater depths, being brought near to the surface here by the fold. Hence, the waters percolating along the porous beds at depths near the center of the valley and acquiring the temperatures appropriate to those depths are here found and tapped near the surface as they rise toward the anticline with the inclosing strata.

High temperatures found near the center of the basin, as in the case of the Payne well or more especially the group at Harlem Springs, can not be explained in this way, as they do not occur in connection with anticlinal structures. There are two or three possible explanations for the presence of these hot waters, but sufficient evidence does not exist to decide between them.

Just as springs in the artesian basins represent leakage to the surface through the impervious cap which confines the waters, and as all the water-bearing horizons in the alluvium probably are imperfectly connected by leakage from one horizon to another, so the hot wells and springs found near the middle of the valley may represent similar leakage from near the bottom of the basin to the surface. Again, the occurrence of strong springs of heated waters along the north edge of the valley, as in the case of the Arrowhead group—waters which sink into the alluvium and are reenforced there perhaps by other flows of hot water from near the fault line, flows which pass directly from the heated rocks of the faulted zone into the alluvium without discharging upon the surface at all—at once suggests that it may be these heated waters percolating seaward through the alluvium along rather definite channels which escape as springs at the head of Warm Creek, or are tapped there by comparatively shallow wells. Of these two hypotheses, leakage from near the bottom of the basin to the surface and percolation of hot water from the fault zone toward the center of the basin, the latter seems the more reasonable as an explanation of the Harlem Springs group, while the former is favored as an explanation of the temperature of waters situated like the Payne well, comparatively near the Bunker Hill dike, which forces heated deep waters toward the surface.

## CHEMICAL CHARACTER OF THE WATERS.

The waters of the San Bernardino artesian basin are very pure, as the subjoined analyses will show. They are, in effect, mountain waters which have passed for a few miles underground through sands and gravels whose drainage is free, so that they have had little opportunity to dissolve the salts contained in the resistant minerals of the rocks.

Professor Hilgard[a] records three analyses, two from groups of wells in the Gage canal system and a third from Warm Creek, at the mill. The results are as follows:

*Analyses of well water, San Bernardino Valley, California.*

[In parts per 100,000.]

| | Gage system artesian wells. | | Warm Creek. |
|---|---|---|---|
| | Group D, No. 5. | Group A, No. 2. | |
| Sodium chloride (common salt) | 0.63 | 0.91 | 2.57 |
| Sodium sulphate (Glauber's salt) | 1.93 | 3.13 | 5.82 |
| Sodium carbonate (sal soda, black alkali) | 1.02 | .21 | 2.00 |
| Potassium sulphate | .60 | .63 | .80 |
| Total soluble residue | 4.18 | 4.88 | 11.19 |
| Calcium sulphate | ..... | .78 | 1.46 |
| Calcium carbonate | 10.17 | 12.12 | 7.62 |
| Magnesium carbonate | 2.32 | 2.49 | 2.53 |
| Silica | 2.44 | 2.39 | 3.24 |
| Total insoluble residue | 14.93 | 17.78 | 14.85 |
| Total solids | 19.11 | 22.66 | 26.04 |

Dr. A. K. Johnson, of San Bernardino, has furnished the following analysis of waters from the Lytle Creek group of wells, which, until recently, furnished all of the water for the San Bernardino system.

[James A. Shedd, analyst.]

| | Parts per 100,000. |
|---|---|
| Sodium chloride | 1.75 |
| Calcium sulphate | 1.71 |
| Calcium carbonate | 5.56 |
| Magnesium carbonate | 3.62 |
| Iron and alumina | 1.4 |
| Silica | 3.75 |
| Total solids | 17.79 |

The following partial analysis of the warm water (112° F.) from the Payne well is from the California Agricultural Experiment Station, E. W. Hilgard, director:

| | Parts per 100,000. |
|---|---|
| Soluble residue (sodium chloride, sodium sulphate, sodium carbonate, potassium sulphate) | 12.56 |
| Insoluble residue: | |
| Calcium sulphate, calcium carbonate, magnesium carbonate, silica (very small) | 22.93 |
| Organic matter and chemically combined water | 2.37 |
| Total | 37.86 |

[a] Hilgard, E. W., Subterranean water supply of the San Bernardino Valley: Report of irrigation investigations for 1901, U. S. Dept. Agric., p. 134.

All of these waters are in constant use for irrigation or for domestic purposes, and the small proportion of salts, particularly of the harmful soluble varieties, makes them very desirable for this use.

Professor Hilgard points out that both the Gage canal and the Warm Creek waters contain percentages of the fertilizing potassium sulphate which are unusual in ground waters and amount to 47 and 6[illegible] pounds per acre, respectively, on the basis of a duty of 1 miner's inch to 5 acres. In the other analyses the potash was not separately determined.

The hot wells and springs of the valley are very generally utilized for baths or medicinal purposes in connection with health resorts. Some complete and partial analyses are available which illustrate their character.

Mr. F. M. Coulter, of Los Angeles, has furnished the following analysis of water from one of the Arrowhead Springs:

*Analysis of water from Arrowhead Springs, California.*

[E. W. Hilgard, analyst.]

| | Parts per 100,000 |
|---|---|
| Sodium chloride (common salt) | 14.1[illegible] |
| Sodium sulphate (Glauber's salt) | 73.4[illegible] |
| Potassium sulphate | 6.9[illegible] |
| Calcium sulphate | 2.3[illegible] |
| Magnesium sulphate | .9[illegible] |
| Calcium carbonate | 2.3[illegible] |
| Magnesium carbonate | .5[illegible] |
| Lithium | Trace |
| Borine | Trace |
| Strontium | Trace |
| Silica | 8.5[illegible] |
| Organic matter | Trace |
| Total solids | 108.5[illegible] |
| Free sulphureted hydrogen, cubic inch per gallon | .62 |

The appended analysis, also made under Professor Hilgard's direction, illustrates the character of the water from the Urbita Hot Springs near San Bernardino:

*Analysis of water from Urbita Springs, California.*

| | Parts per 100,000 |
|---|---|
| Sodium chloride | 3.[illegible] |
| Sodium sulphate, Potassium sulphate (small amount), | 20.[illegible] |
| Sodium carbonate | 7.[illegible] |
| Calcium sulphate, Calcium and magnesium carbonate, | 1.[illegible] |
| Silica | 1.[illegible] |
| Chemically combined water, etc | 8.[illegible] |
| Total | 41.5 |

An old analysis of the Harlem Springs water, accredited to Professor Woodbridge, of Pasadena, shows the following solids present:

*Analysis of water from Harlem Springs, California.*

| | Parts per 100,000. |
|---|---|
| Sodium chloride | 3.89 |
| Sodium sulphate | 14.36 |
| Potassium sulphate | Trace. |
| Sodium carbonate | 3.20 |
| Calcium carbonate, etc | 4.47 |
| Silica | 3.15 |
| Total | 29.07 |

The large proportion of the laxative medicinal salt, sodium sulphate (Glauber's salt), in all these hot waters is worthy of note.

## TABLES OF FLOW.

For a number of years measurements of stream flow and of the amounts of water carried in the various canals of San Bernardino Valley have been made by the United States Geological Survey and by engineers engaged in private practice. The results have been published from time to time in the water-supply papers of the Survey, but for convenience of reference those which are of greatest importance to water users in the valley are assembled in the tables that follow:

### MILL CREEK.

*Discharge measurements of Mill Creek at headworks of Crafton canal, San Bernardino County, Cal..*

| Date. | Hydrographer. | Discharge. |
|---|---|---|
| | | *Second-feet.* |
| July 29, 1896 | J. H. Quinton | 14.2 |
| April 12, 1898 | J. B. Lippincott | 15.7 |
| April 29, 1898 | do | 18.9 |
| June 12, 1898 | do | 18.1 |
| July 23, 1898 | do | 11.8 |
| September 8, 1898 | do | 13.1 |
| October 18, 1898 | F. H. Olmsted | 15.3 |
| November 9, 1898 | do | 15.2 |
| December 8, 1898 | do | 12.6 |
| January 12, 1899 | S. G. Bennett | 10.8 |
| February 18, 1899 | do | 10.4 |
| March 23, 1899 | do | 15.6 |
| May 6, 1899 | do | 14.6 |
| May 31, 1899 | do | 11.6 |
| June 15, 1899 | do | 6.8 |
| July 15, 1899 | do | 7.4 |

*Discharge measurements of Mill Creek at headworks of Crafton canal, etc.*—Continued.

| Date. | Hydrographer. | Discharge. |
|---|---|---|
| | | *Second-feet.* |
| July 27, 1899 | S. G. Bennett | 4.3 |
| August 24, 1899 | do | [a] 5.7 |
| August 24, 1899 | do | [b] 1.5 |
| April 14, 1900 | do | 10.8 |
| May 5, 1900 | do | [a] 39.0 |
| May 5, 1900 | do | [c] 8.0 |
| July 13, 1900 | do | [a] 5.4 |
| July 13, 1900 | do | [b] 3.4 |
| October 2, 1900 | W. W. Cockins, jr | [d] 8.6 |
| March 30, 1901 | S. G. Bennett | 20.0 |
| July 6, 1901 | do | 23.3 |
| December 5, 1901 | do | 14.5 |
| April 5, 1902 | do | 15.7 |
| April 5, 1902 | do | [a] 5.4 |
| May 31, 1902 | do | 19.2 |
| July 10, 1902 | do | 10.8 |
| September 3, 1902 | W. B. Clapp | 5.3 |
| November 5, 1902 | S. G. Bennett | 12.3 |
| April 1, 1903 | W. B. Clapp | 1,280 |
| April 24, 1903 | W. B. Clapp and J. C. Clausen | 39 |
| May 16, 1903 | W. B. Clapp | 68 |
| June 9, 1903 | do | 46 |
| July 1, 1903 | do | 29 |
| September 1, 1903 | do | 22 |
| March 22, 1904 | W. B. Clapp and E. C. Murphy | 17.6 |
| September 21, 1904 | W. B. Clapp | 14.1 |
| November 11, 1904 | E. C. La Rue | 11.2 |

[a] In creek.
[b] Pumped.
[c] Canal.
[d] Of which 1.35 second-feet is pumped.

## SANTA ANA RIVER.

*Discharge measurements of Santa Ana River and canal at Warm Spring, San Bernardino County, Cal.*

| Date. | Hydrographer. | Discharge. |
|---|---|---|
| | | *Second-feet.* |
| June 20, 1896 | J. B. Lippincott | 80.05 |
| July 28, 1896 | J. H. Quinton | 74.70 |
| November 21, 1896 | J. B. Lippincott | 35.18 |
| January 27, 1897 | do | 47.58 |
| March 4, 1897 | do | 105.70 |
| June 15, 1897 | do | 82.74 |
| July 1, 1897 | A. Q. Campbell | 90.79 |
| July 6, 1897 | do | 71.37 |
| August 8, 1897 | do | 74.96 |
| September 30, 1897 | do | 65.48 |
| November 14, 1897 | do | 47.21 |
| January 8, 1898 | do | 34.28 |
| March 9, 1898 | A. H. Crowe | 50.82 |
| April 11, 1898 | J. B. Lippincott | 39.28 |
| April 29, 1898 | do | 42.33 |
| June 12, 1898 | do | 39.06 |
| July 23, 1898 | do | 47.56 |
| September 8, 1898 | do | 36.67 |
| October 18, 1898 | F. H. Olmsted | 30.70 |
| November 9, 1898 | do | 21.78 |
| December 8, 1898 | do | 24.74 |
| January 12, 1899 | S. G. Bennett | 38.00 |
| February 18, 1899 | do | 32.04 |
| March 23, 1899 | do | 37.22 |
| May 6, 1899 | do | 29.24 |
| May 31, 1899 | do | 22.10 |
| June 15, 1899 | do | 19.80 |
| July 15, 1899 | do | 25.90 |
| July 27, 1899 | do | 23.55 |
| August 24, 1899 | do | 10.86 |
| April 14, 1900 | do | 22.66 |
| May 5, 1900 | do | 24.40 |
| July 13, 1900 | do | 22.30 |
| November 20, 1900 | do | 102.00 |
| November 22, 1900 | do | [a] 15.64 |
| February 5, 1901 | do | 101.00 |
| February 23, 1901 | do | 110.00 |
| March 4, 1901 | do | 102.00 |

[a] Calculated.

*Discharge measurements of Santa Ana River and canal at Warm Spring, etc.*—Continued.

| Date. | Hydrographer. | Discharge. |
|---|---|---|
| | | *Second-feet.* |
| March 30, 1901 | S. G. Bennett | 44.60 |
| July 6, 1901 | do | 39.30 |
| August 20, 1901 | do | 30.78 |
| October 8, 1901 | do | 45.20 |
| April 5, 1902 | do | 55.30 |
| May 31, 1902 | do | 29.00 |
| July 10, 1902 | do | 23.50 |
| September 3, 1902 | W. B. Clapp | 24.20 |
| November 5, 1902 | S. G. Bennett | 18.00 |
| February 6, 1903 | W. B. Clapp | 40 |
| April 1, 1903 | do | 4,906 |
| April 2, 1903 | do | 1,068 |
| April 3, 1903 | do | 565 |
| April 24, 1903 | W. B. Clapp and J. C. Clausen | 132 |
| May 16, 1903 | W. B. Clapp | 95 |
| June 30, 1903 | do | 56 |
| August 31, 1903 | do | 41 |
| November 24, 1903 | do | 26 |
| January 29, 1904 | do | 26 |
| March 4, 1904 | do | 33 |
| March 12, 1904 | do | 43 |
| March 22, 1904 | W. B. Clapp and E. C. Murphy | 39 |
| April 20, 1904 | W. B. Clapp | 68 |
| April 21, 1904 | do | 59 |
| May 14, 1904 | do | 36 |
| May 28, 1904 | do | 39 |
| June 29, 1904 | do | 46 |
| September 21, 1904 | do | 58 |
| November 11, 1904 | do | 19 |

## PLUNGE CREEK.

*Discharge measurements of Plunge Creek at the headworks in the canyon, San Bernardino County, Cal.*

| Date. | Hydrographer. | Discharge. |
|---|---|---|
| | | *Second-feet.* |
| June 12, 1898 | J. B. Lippincott | 2.30 |
| September 9, 1898 | do | .20 |
| March 25, 1899 | S. G. Bennett | 10.90 |
| August 25, 1899 | do | .50 |
| July 12, 1900 | do | .34 |
| April 7, 1902 | do | 12.40 |
| September 4, 1902 | W. B. Clapp | .37 |
| April 23, 1903 | W. B. Clapp and J. C. Clausen | 23.00 |
| May 17, 1903 | W. B. Clapp | 9.00 |
| September 11, 1903 | do | .60 |
| September 21, 1904 | do | .60 |

## CITY CREEK.

*Discharge measurements of City Creek at mouth of canyon, San Bernardino County, Cal.*

| Date. | Hydrographer. | Discharge. |
|---|---|---|
| | | *Second-feet.* |
| June 11, 1898 | J. B. Lippincott | 3.03 |
| September 9, 1898 | do | .07 |
| March 25, 1899 | S. G. Bennett | 8.80 |
| August 25, 1899 | do | .17 |
| July 12, 1900 | do | .16 |
| October 1, 1900 | W. W. Cockins, jr | .21 |
| April 7, 1902 | S. G. Bennett | 12.5 |
| September 4, 1902 | W. B. Clapp | .2 |
| April 23, 1903 | W. B. Clapp and J. C. Clausen | 22.00 |
| May 17, 1903 | W. B. Clapp | 11.2 |
| September 11, 1903 | do | .2 |
| September 22, 1904 | do | .5 |

## EAST TWIN CREEK.

*Discharge measurements of East Twin Creek in canyon, San Bernardino County, Cal.*

| Date. | Hydrographer. | Discharge |
|---|---|---|
| | | *Second-feet.* |
| June 11, 1898 | J. B. Lippincott | 2.06 |
| September 9, 1898 | do | .73 |
| March 24, 1899 | S. G. Bennett | 4.58 |
| August 25, 1899 | do | .75 |
| July 12, 1900 | do | .77 |
| October 1, 1900 | W. W. Cockins, jr | .57 |
| April 4, 1902 | S. G. Bennett | 4.9 |
| September 4, 1902 | W. B. Clapp | .4 |
| April 23, 1903 | W. B. Clapp and J. C. Clausen | 10.0 |
| May 17, 1903 | W. B. Clapp | 4.8 |
| September 11, 1903 | do | .4 |
| September 22, 1904 | do | .6 |

## WEST TWIN CREEK.

*Discharge measurements of West Twin Creek in Waterman Canyon, San Bernardino County, Cal.*

| Date. | Hydrographer. | Discharge |
|---|---|---|
| | | *Second-feet.* |
| June 11, 1898 | J. B. Lippincott | 2.1 |
| September 9, 1898 | do | .8 |
| March 21, 1899 | S. G. Bennett | 3.0 |
| August 21, 1899 | do | .2 |
| July 12, 1900 | do | .2 |
| October 1, 1900 | W. W. Cockins, jr | .1 |
| April 4, 1902 | S. G. Bennett | 3.2 |
| September 4, 1902 | W. B. Clapp | .1 |
| April 23, 1903 | W. B. Clapp and J. C. Clausen | 8.6 |
| May 18, 1903 | W. B. Clapp | 4.4 |
| September 11, 1903 | do | .3 |
| September 21, 1904 | do | .4 |

## LYTLE CREEK.

The following measurements were made by A. H. Koebig and G. O. Newman in connection with suits in which the title to the water supply of this creek was involved:

*Discharge measurements of Lytle Creek at mouth of canyon, San Bernardino County, Cal.*

| Date. | Discharge. | Date. | Discharge. |
|---|---|---|---|
| | *Second-feet.* | | *Second-feet.* |
| June 3, 1892 | 35.58 | August 19, 1894 | 11.44 |
| September 20, 1892 | 18.70 | August 25, 1894 | 12.32 |
| September 30, 1892 | 22.04 | October 3, 1894 | 16.20 |
| October 28, 1892 | 20.64 | September 2, 1895 | 56.10 |
| November 21, 1892 | 22.04 | September 30, 1895 | 40.78 |
| November 27, 1892 | 20.68 | March 3, 1896 | 18.08 |
| September 7, 1893 | 49.20 | April 23, 1896 | 19.14 |
| September 18, 1893 | 49.20 | April 24, 1896 | 18.60 |
| September 25, 1893 | 46.34 | April 25, 1896 | 20.52 |
| October 4, 1893 | 45.30 | May 3, 1896 | 18.52 |
| June 6, 1894 | 17.96 | May 4, 1896 | 17.26 |
| June 8, 1894 | 15.50 | May 10, 1896 | 18.16 |
| July 10, 1894 | 13.22 | May 25, 1896 | 15.32 |
| July 11, 1894 | 13.22 | May 26, 1896 | 12.84 |
| July 25, 1894 | 13.36 | | |

The following measurements were made by the United States Geological Survey:

*Discharge measurements of Lytle Creek at mouth of canyon, San Bernardino County, Cal.*

| Date. | Hydrographer. | Discharge. |
|---|---|---|
| | | *Second-feet.* |
| July 24, 1896 | J. H. Quinton | 15.7 |
| June 10, 1898 | J. B. Lippincott | 10.7 |
| August 27, 1898 | F. H. Olmsted | 10.0 |
| August 29, 1899 | S. G. Bennett | 12.5 |
| June 8, 1900 | do | 6.2 |
| September 29, 1900 | W. W. Cockins, jr | 4.6 |
| April 4, 1902 | S. G. Bennett | 19.9 |
| September 5, 1902 | W. B. Clapp | 5.0 |
| April 1, 1903 | do | 1,790.0 |
| April 22, 1903 | W. B. Clapp and J. C. Clausen | 63.0 |
| May 19, 1903 | W. B. Clapp | 29.5 |
| July 2, 1903 | do | 16.5 |
| September 12, 1903 | do | 14.7 |
| September 22, 1904 | do | 9.2 |

## CANALS ABOVE COLTON.

*Comparative amounts of water, in second-feet, flowing in canals above Colton.*

[K. Sanborn, observer.]

| Name of ditch. | 1898. | | 1899. | | | 1900. | | | Sept., 1902. | Aug. and Sept., 1903. | 1904. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June. | Sept. | Mar. | June. | Aug. | Mar. | June. | Sept. | | | May and June. | Aug |
| Barnhill pumping plant | | | | | | | | | | 0.80 | 0.85 | 0.7 |
| Beam ditch | 0.67 | 0.65 | 0.72 | 0.52 | 0.40 | 0.68 | 0.50 | 0.33 | 0.22 | .08 | .02 | .0 |
| Bloomington pumps | 5.26 | 5.49 | (a) | 5.93 | 3.05 | 3.80 | 3.68 | 3.28 | .00 | 8.82 | .00 | 5.0 |
| Brown tract—artesian well | | | | | | | | | | .11 | | |
| Camp Carlton ditch | .61 | 1.20 | 2.13 | 1.62 | 1.02 | 2.55 | 2.60 | 1.67 | 1.70 | 2.20 | 2.50 | 2.0 |
| Carr pumping plant | | | | | | | | | | | | .7 |
| City of Colton (total all pumps) | 6.82 | 7.40 | 3.20 | 5.49 | 3.89 | 4.94 | 3.21 | 3.54 | 3.53 | 3.17 | 3.00 | 2.0 |
| City of San Bernardino | | | | | | | | | | | 2.69 | 2.8 |
| Colton Terrace Water Co. | 1.97 | 1.61 | 1.69 | 1.30 | 1.30 | 1.69 | 1.54 | 1.53 | 1.08 | | .34 | .34 |
| Cooley tract—artesian wells | | | | | | | | | | 2.70 | | |
| Daly ditch | .63 | .67 | .71 | .51 | .51 | .72 | 1.12 | .54 | .00 | | | |
| Gage canal: | | | | | | | | | | | | |
| Diversion | 1.16 | 1.16 | .72 | .24 | .64 | .39 | .29 | .17 | .00 | | | |
| Palm avenue | 26.26 | 25.07 | 26.68 | 25.22 | 23.47 | 21.96 | 22.23 | 27.85 | 30.17 | 30.82 | 27.80 | 31.8 |
| Garner tract—artesian well | | | | | | | | | | .77 | | |
| Haws & Talmage ditch | .84 | .00 | .28 | .00 | .00 | .00 | .00 | .00 | .00 | | | |
| Hunter pumping plant | | | | | | | | | | 1.79 | 1.82 | 1.3 |
| Hurd tract—artesian wells | | | | | | | | | | .21 | | |
| Johnson & Hubbard (pumping plant) | | | | | | | | | | .42 | .67 | .5 |
| Lamb pumping plant | | | | | | | | | | .24 | .24 | .2 |
| Lawson Well Co. | | | | | | | | | | .59 | .65 | .5 |
| Logsdon & Farrell ditch | .72 | .63 | 1.61 | 1.15 | .54 | 1.26 | .49 | .20 | .00 | | | |
| Lytle Creek Water and Improvement Co. | | | | | | | | | | | | 4.0 |
| McIntyre ditch | .37 | .04 | .82 | .15 | .00 | .14 | .01 | .00 | .00 | | | |
| McKenzie ditch | 2.54 | 2.08 | 9.40 | 3.86 | 2.00 | 2.30 | 1.57 | 1.69 | .00 | .00 | .67 | .5 |
| Meeks & Daly ditch | 8.42 | 17.00 | 17.00 | 15.48 | 10.45 | 13.94 | 13.78 | 14.68 | 13.40 | 12.87 | 16.30 | 16.7 |
| Merryfield pumping plant | | | | | | | | | | | .90 | .9 |
| Mount Vernon Water Co. | | | | | | | | | | | 91 | .9 |
| Orange Land and Water Co | | | | | | | | | | 1.08 | 1.14 | 1.1 |
| Rabel Dam ditch | 5.37 | 3.07 | 2.36 | 1.54 | .94 | .54 | .35 | .07 | .00 | | | |
| Ranchero pumping plant | 1.75 | 1.64 | 1.64 | 1.00 | .41 | .24 | .55 | 1.33 | 2.28 | 1.09 | 1.46 | 1.3 |
| Riverside Highlands Water Co (Lytle Creek) | 4.40 | 4.43 | 4.25 | 2.08 | 2.00 | 6.59 | 5.38 | 3.70 | | 8.98 | 7.92 | 2.0 |
| Riverside Highlands Water Co. (Santa Ana River) | | | | | | | | | | | | 6.8 |
| Riverside Water Co. (Flume Pump No. 1) | | | | | | | | | 5.03 | 4.08 | .79 | 2.2 |
| Riverside Water Co. (Flume Pump No. 2) | | | | | | | | | | 2.63 | 1.76 | 2.3 |
| Riverside Water Co. (mill flume) | 3.12 | 3.36 | 5.30 | 7.29 | 2.56 | 2.67 | 2.17 | .94 | .50 | .00 | 2.68 | .0 |
| Riverside Water Co. (mill pump) | 1.94 | 2.04 | (a) | 1.77 | 1.67 | (a) | 1.88 | 1.52 | 1.20 | | 1.32 | 1.8 |
| Riverside Water Co. (River Ditch Pump No. 1) | | | | | | | | | | 5.79 | 5.47 | 4.2 |
| Riverside Water Co. (River Ditch Pump No. 2) | | | | | | | | | | | 3.86 | 4.2 |

a Pumps not run.

*Comparative amounts of water, in second-feet, flowing in canals above Colton*—Continued.

| Name of ditch. | 1898. | | 1899. | | | 1900. | | | Sept., 1902. | Aug. and Sept., 1903. | 1904. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June. | Sept. | Mar. | June. | Aug. | Mar. | June. | Sept. | | | May and June. | Aug. |
| Riverside Water Co. (upper canal) | 59.04 | 61.34 | 60.53 | 53.92 | 52.04 | 61.94 | 52.94 | 61.02 | 47.97 | 55.90 | 42.40 | 38.13 |
| Rogers pumping plant | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 4.38 | 4.44 | ..... | ..... |
| Rosedale Water Co. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | .60 | .50 |
| Shay & Stout ditch | 2.30 | 2.08 | 2.23 | 1.13 | .90 | .51 | .40 | .16 | .00 | ..... | ..... | ..... |
| Swamp ditch | 1.00 | 1.02 | .85 | .77 | .69 | .70 | .89 | .86 | .93 | .42 | .51 | .47 |
| Ward & Warren ditch | 2.32 | 2.32 | 3.09 | .62 | 1.56 | 2.55 | 1.70 | .53 | 1.88 | 1.61 | ..... | ..... |
| West Riverside 350-inch pumping plant | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 5.94 | 3.41 | 6.52 | 5.35 |
| Whiting ditch | .26 | .01 | .76 | .25 | .01 | 1.12 | .13 | .00 | .00 | ..... | ..... | ..... |
| Whitlock ditch | .34 | .38 | .47 | .28 | .09 | .23 | .00 | .00 | .00 | ..... | ..... | ..... |
| Wozencraft tract artesian well | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | .23 | ..... | ..... |
| Total | 138.11 | 144.69 | 146.44 | 132.11 | 110.14 | 131.46 | 117.41 | 125.61 | 120.21 | 155.25 | 123.24 | 127.86 |

## LIST OF WELLS.

In Water-Supply Paper No. 60, Mr. J. B. Lippincott published lists of the most important of the wells in the Redlands and San Bernardino quadrangles. The edition of this paper was exhausted soon after its issue; therefore the lists are here republished. No attempt has been made to revisit all wells or to secure complete revised data on water levels and yield, and such evidence as has been secured on the first of these points appears in Pl. VII and in the tables on pages 57 and 58. The data, therefore, as they are published here, represent conditions as they existed in 1900.

*Wells in Redlands quadrangle.*

[*Abbreviations used in well records.*—Under "Method of lift:" Hand=hand pump. Horse=horsepower machine. Electric=an electric motor. Centrifugal=a centrifugal pump. Gas=a gasoline engine. Wind=a windmill. 14 wind=that water is pumped by a 14-foot windmill. In case of the gasoline engines, electric motors, etc., the accompanying figures indicate the horsepower. Under "quantity of water:" Good indicates a good supply of water. Small indicates a small or deficient supply of water.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 1 | Doctor Meeker | Sec. 16, T. 1 S., R. 2 W. | 1900 | Dug, 4 by 6 foot | 1,995 | 1,718 | 130 | | $1,100 | | | |
| 2 | Ward, Mills & Co. | Sec. 21, T. 1 S., R. 2 W. | 1900 | do | 2,005 | 1,933 | 125 | Gas | 750 | | | |
| 3 | Crafton Water Co. | Sec. 7, T. 1 S., R. 1 W. | 1900 | Dug, 5 by 6 foot | 3,010 | 2,992 | 132 | Centrifugal; electric | 2,000 | $2,500 | 1.38 | Irrigation. |
| 4 | do | Sec. 8, T. 1 S., R. 1 W. | 1900 | Dug, 5½ by 6½ foot. | 3,650 | 3,648 | 98 | do | [a] 6,000 | 2,500 | 2.70 | Do. |
| 5 | Mrs. M. A. Brown | Sec. 22, T. 1 S., R. 2 W. | 1879 | Dug, 4 by 4 foot | 2,250 | 2,225 | 27 | Wind | | 100 | | Domestic. |
| 6 | Geo. McIntosh | do | 1899 | do | 2,230 | 2,189 | 70 | Centrifugal; electric | | | | Irrigation. |
| 7 | R. P. McIntosh | Sec. 20, T. 1 S., R. 2 W. | 1900 | Dug, 4½ by 4½ foot. | 1,910 | 1,818 | 103 | Cylinder pump; gas | 700 | 925 | .14 | Do. |
| 8 | L. Lodge | Sec. 16, T. 1 S., R. 2 W. | 1900 | Dug, 4 by 6 foot | 2,060 | 2,050 | 70 | do | | 1,500 | .30 | Do. |
| 9 | L. Lyons | do | 1900 | do | 2,075 | 2,052 | | do | | | | Do. |
| 10 | T. P. Christian | Sec. 17, T. 1 S., R. 2 W. | 1900 | do | 1,900 | 1,748 | 180 | do | | 1,500 | | Do. |
| 11 | F. Wieder | Sec. 29, T. 1 S., R. 2 W. | 1900 | Dug, 4 by 5 foot | 1,830 | 1,779 | 100 | do | 450 | 950 | | Do. |
| 12 | E. J. Roberts | Sec. 28, T. 1 S., R. 2 W. | (b) | Dug, 4 by 6 foot | 2,200 | 2,192 | | Horse | 300 | | | Do. |
| 13 | H. H. Garstin | Sec. 29, T. 1 S., R. 2 W. | 1900 | Bored, 10-inch | 2,000 | 1,905 | 241 | Cylinder pump; gas | 800 | 1,430 | .06 | Do. |
| 14 | W. J. Tench | Sec. 19, T. 1 S., R. 2 W. | | Dug, 4 by 6 foot | 1,720 | 1,560 | 163 | | | | | Irrigation; domestic. |
| 15 | East Redlands Water Co. | Sec. 36, T. 1 S., R. 3 W. | 1900 | Bored, 12-inch | 1,805 | 1,621 | 514 | Cylinder pump; gas | 2,200 | | .32 | Irrigation. |
| 16 | E. & D. Conkling | Sec. 31, T. 1 S., R. 2 W. | 1899 | Bored, 10-inch | 1,795 | 1,545 | 350 | do | | 2,200 | .40 | Do. |
| 17 | M. S. Crosswell | Sec. 24, T. 1 S., R. 3 W. | | Dug, 4 by 6 foot | 1,540 | 1,378 | 163 | do | | | .12 | Do. |
| 18 | | Sec. 33, T. 1 S., R. 2 W. | | Dug, 2½ by 4 foot | 2,120 | 2,060 | 60 | | | | | |
| 19 | Mr. Gregory | do | 1892 | Dug | 2,130 | 2,123 | 10 | Hand | 20 | | | Domestic. |
| 20 | Dunlap estate | Sec. 4, T. 2 S., R. 2 W. | 1899 | Bored, 10-inch | 2,040 | 2,040 | | Centrifugal; gas | | | .50 | Irrigation. |
| 21 | do | do | 1895 | Bored, 7-inch | 2,075 | 2,077 | 142 | Artesian | | | .005 | Domestic. |
| 22 | do | do | 1900 | Bored, 10-inch | 2,100 | 2,100 | 800 | do | 2,950 | | .015 | Irrigation. |
| 23 | do | do | 1900 | do | 2,090 | 2,090 | | do | | | | Do. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Houghton & McNee | do | 1895 | Dug, 3 by 4 foot | 2,270 | 2,227 | 43 | Wind | | | | Domestic. |
| 25 | Geo. Clyde (tunnel) | Sec. 26, T. 1 S., R. 2 W. | | Hydraulic, 4 by 6 foot. | 2,700 | 2,700 | 97 | Gravity | [c] 300 | | .02 | Irrigation; domestic. |
| 26 | Mr. Biggin | Sec. 34, T. 1 S., R. 2 W. | 1899 | Dug, 6 by 6 foot | 2,224 | 2,163 | 65 | | | | .16 | |
| 27 | South Mountain Water Co. | Sec. 33, T. 1 S., R. 2 W. | 1900 | Bored, 10-inch | 2,160 | 2,132 | 965+ | Centrifugal; steam | | | | Irrigation. |
| 28 | Garland estate | Sec. 25, T. 1 S., R. 3 W. | 1900 | do | 1,570 | 1,394 | | Cylinder pump; gas | | | | Do. |
| 29 | C. D. Fowler | Sec. 5, T. 1 S., R. 3 W. | 1891 | do | 1,180 | 1,125 | 70 | | | | | |
| 30 | West Redlands Water Co. | Sec. 35, T. 1 S., R. 3 W. | 1899 | Bored, 12-inch | 1,600 | 1,530 | 226 | Cylinder pump; gas | 1,250 | 2,500 | .40 | Do. |
| 31 | do | do | 1899 | Bored, 10-inch | 1,620 | 1,529 | 248 | | 1,080 | | | Do. |
| 32 | do | do | 1899 | Bored, 12-inch | 1,626 | 1,536 | 243 | Cylinder pump; gas | 1,700 | 2,500 | .36 | Do. |
| 33 | Redlands Heights Water Co. | Sec. 1, T. 2 S., R. 3 W. | 1900 | Bored, 10-inch | 1,880 | | 300 | | 1,200 | | | Do. |
| 34 | Mr. Painter (?) | Sec. 8, T. 2 S., R. 2 W. | 1899 | Dug, 4 by 6 foot | 1,975 | 1,932 | 60 | | | | | |
| 35 | do | do | 1899 | do | 1,975 | 1,932 | 46 | | | | | |
| 36 | Mrs. Diaz | Sec. 14, T. 2 S., R. 3 W. | | Bored, 7-inch | 1,545 | 1,456 | 96 | Hand | 125 | 20 | | Domestic. |
| 37 | C. W. Blue | do | 1898 | do | 1,523 | 1,455 | 110 | Wind | 200 | 75 | | Domestic; irrigation. |
| 38 | A. Gregory | Sec. 27, T. 1 S., R. 3 W. | 1895 | do | 1,379 | 1,274 | 168 | do | 250 | 500 | .016 | Domestic. |
| 39 | W. McConkey | do | 1898 | do | 1,380 | | | do | | | | Do. |
| 40 | D. Madell | do | 1898 | do | 1,377 | 1,277 | 171 | do | 274 | | .001 | Do. |
| 41 | G. H. Garland | Sec. 26, T. 1 S., R. 3 W. | 1899 | Bored, 10-inch | 1,450 | 1,261 | 246 | Cylinder pump; gas | | 3,000 | .40 | Irrigation. |
| 42 | C. L. Hayes | Sec. 27, T. 1 S., R. 3 W. | 1899 | do | 1,420 | 1,270 | 428 | do | 850 | 1,400 | .30 | Do. |
| 43 | O. W. Harris | Sec. 34, T. 1 S., R. 3 W. | 1895 | Bored, 7-inch | 1,503 | 1,303 | 312 | Cylinder pump; electric. | 600 | 800 | .075 | Do. |
| 44 | Horace Evans | Sec. 33, T. 1 S., R. 3 W. | 1899 | Bored, 10-inch | 1,455 | 1,259 | 660 | Cylinder pump; gas | 1,900 | 1,400 | .18 | Irrigation; domestic. |
| 45 | A. C. Fowler | Sec. 32, T. 1 S., R. 3 W. | 1898 | Bored, 9-inch | 1,250 | 1,140 | 170 | do | 250 | 300 | .10 | Irrigation. |
| 46 | L. C. Smith | do | 1898 | Dug, 3 by 3 foot | 1,215 | 1,135 | 83 | Wind | 90 | 65 | .003 | Domestic. |
| 47 | P. B. Fussell | do | 1897 | Bored, 12-inch | 1,253 | 1,195 | 165 | do | 330 | 230 | | Irrigation; domestic. |
| 48 | E. Vache | do | 1885 | Bored, 7-inch | 1,260 | 1,200 | 140 | do | 170 | 75 | | Domestic. |
| 49 | | Sec. 4, T. 2 S., R. 3 W. | 1893 | do | 1,350 | 1,290 | 150 | do | | | | Stock. |
| 50 | W. D. Covington | do | 1893 | do | 1,325 | 1,290 | 157 | Hand | 350 | 20 | Small. | Do. |
| 51 | do | do | 1893 | Bored, 10-inch | 1,300 | 1,300 | 750 | Artesian | 2,000 | | .002 | Domestic; stock. |
| 52 | D. S. Jordan | do | 1899 | Bored, 7-inch | 1,395 | 1,379 | 56 | Wind | 80 | 90 | .001 | Domestic; irrigation. |

[a] Well and tunnel 250 feet long. [b] Not completed. [c] Tunnel 97 feet long.

*Wells in Redlands quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 53 | Redlands Domestic Water Co. | Sec. 35, T. 1 S., R. 3 W.. | 1899 | Bored, 10-inch.... | 1,560 | 1,503 | ..... | Centrifugal; electric .... | $1,800 | ..... | 0.80 | Domestic; irrigation. |
| 54 | Wood, Bill & Davis..... | Sec. 33, T. 1 S., R. 3 W.. | 1899 | .....do ..... | 1,305 | 1,225 | 462 | Cylinder pump; gas..... | 1,200 | $1,800 | .40 | Do. |
| 55 | D. H. Gillan ..... | Sec 32, T. 1 S., R. 3 W.. | 1899 | Bored, 8-inch..... | 1,245 | 1,157 | 438 | Air compressor; gas..... | ..... | 3,000 | .50 | Do. |
| 56 | H. Bermudas..... | .....do ..... | 1893 | Bored, 7-inch..... | 1,210 | 1,156 | 112 | Hand..... | ..... | 3 | ..... | Domestic. |
| 57 | N. B. Hinckley estate..... | .....do ..... | ..... | Bored, 10-inch.... | 1,177 | 1,021 | 700+ | Wind ..... | ..... | ..... | ..... | Domestic; irrigation. |
| 58 | Wm. Curtis..... | Sec. 30, T. 1 S., R. 3 W.. | 1885 | .....do ..... | 1,144 | 1,076 | 76 | .....do ..... | 150 | 100 | .002 | Domestic. |
| 59 | E. C. Curtis..... | Sec 29, T. 1 S., R. 3 W.. | 1895 | Bored, 7-inch..... | 1,120 | 1,070 | 96 | .....do ..... | 160 | 75 | .002 | Do. |
| 60 | R. T. Curtis..... | .....do ..... | 1895 | .....do ..... | 1,123 | 1,073 | 86 | .....do ..... | 140 | 100 | .003 | Do. |
| 61 | W. M. Curtis..... | .....do ..... | 1899 | Bored, 12-inch.... | 1,125 | 1,079 | 415 | Cylinder pump; gas..... | 900 | 1,800 | .70 | Irrigation. |
| 62 | N. B. Curtis..... | .....do ..... | 1895 | Bored, 7-inch..... | 1,126 | 1,076 | 84 | Wind ..... | 140 | 60 | .001 | Domestic. |
| 63 | N. B. Hinckley estate..... | Sec. 30, T. 1 S., R. 3 W.. | 1899 | Bored, 36-inch....<br>Bored, 11-inch.... | 1,150 | 1,103 | 65<br>271 | Centrifugal; gas..... | 900 | 800 | .42 | Irrigation. |
| 64 | L. & M. Frink ..... | .....do ..... | 1889 | Bored, 7-inch..... | 1,140 | 1,112 | 62 | Wind ..... | 100 | 163 | ..... | Domestic. |
| 65 | Mrs. P. S. Stewart..... | .....do ..... | 1898 | .....do ..... | 1,144 | 1,109 | 76 | .....do ..... | 150 | 65 | .001 | Do. |
| 66 | Gansnor & Renwick ..... | .....do ..... | 1898 | .....do ..... | 1,140 | 1,110 | 200 | .....do ..... | 320 | 90 | .003 | Domestic; irrigation. |
| 67 | Redlands Water Co ..... | Sec. 35, T. 1 S., R. 3 W.. | 1899 | Bored, 10-inch.... | 1,563 | ..... | ..... | Centrifugal; electric .... | ..... | ..... | ..... | Irrigation. |
| 68 | Mrs. M. Robison ..... | Sec. 30, T. 1 S., R. 3 W.. | 1870 | Dug, 3-foot..... | 1,110 | ..... | 24 | Hand..... | ..... | ..... | Dry. | |
| 69 | Southern Pacific R. R. Co.. | Sec. 31, T. 1 S., R. 3 W.. | 1890 | Bored, 7-inch..... | 1,176 | 1,116 | 75 | .....do ..... | 145 | 20 | ..... | Domestic. |
| 70 | W. F. Whittier..... | .....do ..... | 1898 | Bored, 10-inch....<br>Bored, 7-inch..... | 1,410 | 1,208 | 294<br>212 | Cylinder pump; gas..... | 1,000 | 985 | .14 | Domestic; irrigation. |
| 71 | .....do..... | .....do ..... | 1898 | Bored, 14-inch....<br>Bored, 10-inch.... | 1,150 | 1,108 | 276<br>84 | Force pump; gas ..... | 1,020 | ..... | .80 | Irrigation. |
| 72 | Owen Buchanan..... | .....do ..... | 1898 | Bored, 7-inch..... | 1,265 | 1,149 | 237 | Cylinder pump; gas..... | 379 | 800 | .14 | Do. |
| 73 | W. J. Lawrence..... | .....do ..... | 1898 | .....do ..... | 1,230 | 1,141 | 190 | .....do ..... | 304 | 700 | .12 | Do. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 74 | Frink Bros | Sec. 30, T. 1 S., R. 3 W. | 1899 | Bored, 36-inch; bored, 10-inch. | 1,147 | 1,105 | 335 | Centrifugal; gas | 800 | 700 | .62 | Do. |
| 75 | Rhoda Wilson | do | 1899 | Bored, 7-inch | 1,138 | | 59 | Wind | 95 | 65 | .001 | Domestic. |
| 76 | D. Van Leuven | do | 1900 | Bored, 9-inch | 1,132 | 1,098 | 63 | Hand | 65 | 14 | | Do. |
| 77 | E. Hankins | Sec. 28, T. 1 S., R. 3 W. | 1899 | Bored, 12-inch | 1,254 | 1,200 | 290 | Cylinder pump; gas | 800 | 1,300 | .40 | Irrigation; domestic. |
| 78 | J. A. Osborn | do | 1899 | Bored, 10-inch | 1,225 | 1,173 | 320 | Centrifugal; gas | 880 | | .50 | Do. |
| 79 | do | do | | Bored, 7-inch | 1,224 | 1,174 | 190 | Wind | 300 | 72 | .001 | Domestic. |
| 80 | Mrs. S. W. Sylvera | Sec. 29, T. 1 S., R. 3 W. | 1891 | do | 1,200 | 1,170 | 90 | do | | 80 | .001 | Do. |
| 81 | A. B. Cook | do | 1897 | Bored, 10-inch | 1,206 | 1,166 | 110 | Centrifugal; gas | 220 | 800 | .40 | Domestic; irrigation. |
| 82 | S. Mansfield | do | 1900 | do | 1,195 | 1,163 | 340 | | | | | |
| 83 | do | do | 1890 | Bored, 7-inch | 1,193 | 1,154 | 109 | Wind | 175 | | Small. | Do. |
| 84 | A. Lenanon | do | 1895 | do | 1,186 | 1,156 | 130 | Cylinder pump; horse | 208 | 40 | | Domestic. |
| 85 | John Furney | do | 1890 | do | 1,179 | 1,139 | 60 | Wind | 100 | 150 | .008 | Domestic; irrigation. |
| 86 | Barton Land and Water Co. | do | 1891 | do | 1,180 | 1,137 | 63 | Hand | 100 | | | Domestic. |
| 87 | M. D. Easton | do | 1890 | do | 1,121 | 1,101 | 45 | Wind | 80 | 70 | .008 | Do. |
| 88 | Barton Land and Water Co. | do | 1891 | do | 1,130 | 1,100 | 48 | Hand | | | | Do. |
| 89 | J. R. Campbell | do | 1898 | do | 1,190 | 1,155 | 108 | do | 190 | 25 | | Do. |
| 90 | Carl Furst | do | 1891 | Bored, 5¼-inch | 1,215 | 1,180 | 114 | do | 165 | 35 | | Do. |
| 91 | S. E. Rockwell | do | 1900 | Bored, 10-inch | 1,200 | 1,170 | 356 | Cylinder pump; gas | 1,000 | 860 | .34 | Irrigation. |
| 92 | J. Hickey | do | 1898 | Bored, 9¼-inch | 1,226 | 1,190 | 152 | do | 314 | 700 | .20 | Irrigation; domestic. |
| 93 | B. M. James | do | 1899 | Bored, 10-inch | 1,230 | 1,198 | 220 | do | 418 | 900 | .34 | Do. |
| 94 | W. A. Nichols | Sec. 28, T. 1 S., R. 3 W. | 1891 | Bored, 7-inch | 1,246 | 1,194 | 122 | Hand | | | | Domestic. |
| 95 | do | do | | Bored, 10-inch | 1,255 | 1,206 | 284 | Cylinder pump; gas | 530 | 1,000 | .36 | Irrigation. |
| 96 | W. D. Tobey | Sec. 29, T. 1 S., R. 3 W. | | do | 1,204 | | 324 | do | | | | Do. |
| 97 | S. A. Grover | Sec. 28, T. 1 S., R. 3 W. | 1899 | do | 1,253 | 1,183 | 231 | do | 700 | 1,100 | .40 | Domestic; irrigation. |
| 98 | Schee Bros | do | 1899 | do | 1,280 | 1,210 | 425 | do | 1,400 | 1,500 | .50 | Do. |
| 99 | W. F. Schee | do | 1894 | Bored, 7-inch | 1,291 | | | do | | | | Irrigation. |
| 100 | Redlands Water Co | Sec. 35, T. 1 S., R. 3 W. | 1899 | Bored, 10-inch | 1,565 | | | Centrifugal; steam | | | 1.56 | Do. |
| 101 | Barton Land and Water Co. | Sec. 28, T. 1 S., R. 3 W. | 1900 | do | 1,315 | 1,225 | 250 | | | | | |
| 102 | Willis Miller | Sec. 21, T. 1 S., R. 3 W. | 1898 | Bored, 7-inch | 1,290 | 1,208 | 123 | Wind | 200 | 125 | .002 | Domestic. |

*Wells in Redlands quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 103 | S. A. Grover | Sec. 21, T. 1 S., R. 3 W. | 1890 | Bored, 7-inch | 1,294 | ..... | ..... | Wind | ..... | ..... | ..... | Domestic; irrigation. |
| 104 | C. Cutting | do | 1894 | do | 1,320 | 1,220 | 170 | Cylinder pump; gas | $337 | $340 | ..... | Do. |
| 105 | Myron Sherman | Sec. 27, T. 1 S., R. 3 W. | 1892 | Bored, 8-inch | 1,331 | 1,221 | 145 | Cylinder pump; electric. | 450 | 300 | ..... | Do. |
| 106 | J. S. Hale | Sec. 21, T. 1 S., R. 3 W. | 1897 | Bored, 11-inch | 1,272 | 1,202 | 295 | Cylinder pump; gas | 600 | 1,300 | 0.48 | Irrigation. |
| 107 | do | do | 1890 | Bored, 7-inch | 1,265 | 1,201 | 105 | Wind | 159 | 200 | .002 | Domestic; irrigation. |
| 108 | do | Sec. 17, T. 1 S., R. 3 W. | 1896 | Bored, 10-inch | 1,220 | 1,164 | 86 | do | 160 | 75 | .015 | Irrigation. |
| 109 | C. A. Shaw | Sec. 21, T. 1 S., R. 3 W. | 1893 | Bored, 7-inch | 1,267 | 1,217 | 96 | do | 138 | 87 | .005 | Domestic; irrigation. |
| 110 | Lewis Deck | do | 1895 | do | 1,278 | 1,213 | 220 | Cylinder pump; gas | 363 | 678 | .15 | Do. |
| 110a | do | do | 1895 | do | 1,278 | 1,213 | 150 | do | ..... | ..... | .15 | Do. |
| 111 | I. E. Shaw | do | 1890 | do | 1,247 | 1,197 | 90 | Hand | 150 | 25 | ..... | Domestic. |
| 112 | Alise Van A. Lea | do | 1898 | Bored (2) | 1,258 | ..... | 70<br>130 | Cylinder pump; gas | 500 | 700 | ..... | Not used. |
| 113 | A. Gregory | do | 1890 | Bored, 7-inch | 1,245 | 1,194 | 100 | Wind | ..... | ..... | ..... | Domestic. |
| 114 | Gladysta Land and Water Co. | Sec. 20, T. 1 S., R. 3 W. | 1899 | Bored, 11-inch | 1,240 | ..... | ..... | Cylinder pump; gas | ..... | ..... | ..... | Irrigation. |
| 115 | Frank Hess | Sec. 21, T. 1 S., R. 3 W. | 1897 | do | 1,243 | 1,188 | 163 | Centrifugal; gas | 326 | 800 | .24 | Domestic; irrigation. |
| 116 | C. S. Lombard | Sec. 16, T. 1 S., R. 3 W. | 1897 | Bored, 10-inch | 1,246 | 1,182 | 180 | Cylinder pump; gas | ..... | ..... | .30 | Do. |
| 117 | S. Ronzone | do | 1899 | Bored, 9-inch | 1,257 | 1,192 | 98 | Wind | 235 | 200 | .014 | Do. |
| 118 | Thos. Blakeley | do | ..... | Bored | 1,254 | ..... | ..... | Electric | ..... | ..... | ..... | Irrigation. |
| 119 | Elza Boger | do | 1899 | Dug, 4 by 4 foot; bored, 9-inch. | 1,255 | 1,185 | 132 | (a) | ..... | ..... | ..... | |
| 120 | M. R. Gay | Sec. 17, T. 1 S., R. 3 W. | 1896 | Bored, 11-inch (2). | 1,220 | 1,170 | 105 | Air compressor; electric. | 200 | ..... | .22 | Do. |
| 121 | W. W. Story | Sec. 16, T. 1 S., R. 3 W. | 1900 | Bored, 10-inch | 1,262 | 1,193 | 168 | Cylinder pump; gas | 400 | 1,500 | .50 | Domestic; irrigation. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 122 | John Dostal | Sec. 15, T. 1 S., R. 3 W. | 1897 | do | 1,403 | 1,230 | 174 | Wind | 345 | 140 | Small. | Domestic. |
| 123 | J. F. Boyd | Sec. 16, T. 1 S., R. 3 W. | 1896 | Bored, 10-inch (2). | 1,290 | 1,180 | 100<br>110 | Cylinder pump; gas | 500 | 900 | .20 | Irrigation; domestic. |
| 124 | Wm. Lindenberg | Sec. 20, T. 1 S., R. 3 W. | 1893 | Bored, 7-inch | 1,220 | 1,180 | 98 | Wind | 140 | 150 | .009 | Do. |
| 125 | H. S. Drew | Sec. 19, T. 1 S., R. 3 W. | | Bored, 14-inch<br>Bored, 10-inch | 1,167 | 1,133 | 164<br>291 | Cylinder pump; gas | 1,300 | 1,500 | .60 | Do. |
| 126 | James Smith | do | 1892 | Bored, 7-inch | 1,164 | 1,130 | 90 | Hand | 150 | 10 | | Domestic. |
| 127 | Bryan estate | Sec. 20, T. 1 S., R. 3 W. | 1900 | Bored, 10-inch<br>Bored, 8-inch | 1,190 | 1,143 | 510<br>118 | Centrifugal; gas | | | .40 | Irrigation. |
| 128 | A. M. Ham | Sec. 30, T. 1 S., R. 3 W. | 1887 | Bored, 7-inch<br>Bored, 5-inch | 1,155 | 1,120 | 150<br>300 | Cylinder pump; gas | 1,500 | 900 | | Domestic; irrigation. |
| 129 | P. H. Covington | Sec. 10, T. 2 S., R. 3 W. | | Bored, 7-inch | 1,440 | 1,392 | 58 | Hand | | | | |
| 130 | Clark & Brotherton | Sec. 20, T. 1 S., R. 3 W. | 1900 | Bored, 10-inch; bored, 8¼-inch. | 1,195 | 1,162 | | (a) | | | | Domestic. |
| 131 | J. J. Prendergast | Sec. 29, T. 1 S., R. 3 W. | 1893 | Bored, 10-inch | 1,200 | 1,166 | 422 | Cylinder pump; gas | 1,200 | 800 | .30 | Irrigation; domestic. |
| 132 | H. H. Cole | Sec. 30, T. 1 S., R. 3 W. | 1888 | Bored, 7-inch | 1,140 | 1,108 | 82 | Wind | 140 | 180 | Small. | Do. |
| 133 | H. S. Drew | Sec. 19, T. 1 S., R. 3 W. | 1886 | do | 1,138 | | 70 | do | 140 | 150 | .001 | Domestic. |
| 134 | C. M. Baxter | Sec. 30, T. 1 S., R. 3 W. | 1899 | Bored, 10-inch | 1,147 | 1,116 | 100 | Centrifugal; gas | | | .60 | Irrigation. |
| 135 | do | do | 1892 | Bored, 7-inch | 1,147 | 1,113 | 80 | Hand | | | | Domestic. |
| 136 | C. H. Lehmann | Sec. 19, T, 1 S., R. 3 W. | 1891 | Bored, 10-inch | 1,129 | 1,103 | 458 | Cylinder pump; gas | 1,300 | 900 | .40 | Irrigation; domestic. |
| 137 | A. E. Cole | Sec. 30, T. 1 S., R. 3 W. | 1892 | Bored, 7-inch | 1,125 | 1,104 | 100 | Wind | 160 | 100 | .005 | Do. |
| 138 | A. McCrary | do | 1891 | do | 1,120 | 1,093 | 40 | Hand | 64 | | | Domestic. |
| 139 | H. R. Scott | Sec. 19, T. 1 S., R. 3 W. | | do | 1,120 | 1,108 | 503 | Centrifugal; gas | 1,000 | 1,000 | | Irrigation; domestic. |
| 140 | do | do | 1879 | Bored, 6-inch | 1,127 | 1,109 | 500 | | | | | |
| 141 | E. H. Durnford | Sec. 24, T. 1 S., R. 4 W. | 1894 | Bored, 7-inch | 1,103 | 1,093 | 500 | Centrifugal; gas | | | .60 | Domestic; irrigation. |
| 142 | James Birch | do | 1890 | do | 1,096 | 1,087 | 300 | | | | | Domestic. |
| 143 | do | do | | do | 1,098 | 1,081 | 100 | | | | | |
| 144 | D. W. Roach | do | 1899 | do | 1,102 | 1,087 | 85 | Hand | 130 | 24 | | Do. |
| 145 | E. F. Van Leuven | Sec. 25, T. 1 S., R. 4 W. | 1890 | do | 1,103 | 1,083 | 48 | Wind | | | .001 | Do. |
| 147 | W. J. Doran | Sec. 30, T. 1 S., R. 3 W. | 1900 | Bored, 10-inch | 1,106 | 1,086 | 100 | do | 200 | | | Do. |
| 148 | L. R. Van Leuven | do | 1882 | Bored, 7-inch | 1,108 | 1,093 | 270 | do | 600 | 109 | .001 | Domestic; irrigation. |

a Unfinished.

*Wells in Redlands quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 149 | | Sec. 30, T. 1 S., R. 3 W. | | Bored, 7-inch | 1,120 | | | Wind | | | | Domestic; irrigation. |
| 150 | O. Taylor | Sec. 32, T. 1 S., R. 3 W. | 1897 | do | 1,210 | | 75 | do | | $120 | 0.003 | Do. |
| 151 | H. C. Hamanway | do | | do | 1,209 | | | Hand | | | | |
| 152 | G. J. Grant | do | 1896 | Bored, 7-inch (2) | 1,206 | | | Gas | | | | Irrigation; domestic. |
| 153 | S. L. Gregg | do | | Bored, 7-inch | 1,202 | | | Wind | | | | Domestic. |
| 154 | H. C. Hamanway | do | 1899 | Bored, 10-inch | 1,250 | 1,198 | 200 | Cylinder pump; gas | | | .32 | Irrigation. |
| 155 | T. Morris | do | 1890 | Bored, 7-inch | 1,260 | 1,195 | 125 | Wind | | | .002 | Irrigation; domestic. |
| 156 | S. V. Horton | do | 1891 | do | 1,270 | 1,195 | 125 | do | $200 | 175 | .01 | Do. |
| 157 | C. T. Covington | Sec. 4, T. 2 S., R. 3 W. | 1891 | do | 1,455 | 1,415 | 65 | Hand | 100 | 25 | | Domestic. |
| 158 | Mrs. Van Leuven | Sec. 25, T. 1 S., R. 4 W. | 1896 | do | 1,105 | 1,085 | 78 | do | 150 | 15 | | Do. |
| 159 | J. H. Pierson | Sec. 24, T. 1 S., R. 4 W. | 1884 | Bored, 6-inch | 1,104 | 1,108 | 605 | Centrifugal; gas | 10,222 | 1,200 | .60 | Domestic; irrigation. |
| 160 | F. M. Strang | Sec. 10, T. 2 S., R. 3 W. | 1897 | Dug, 3 by 3 foot | 1,500 | 1,423 | 79 | Hand | 77 | 4 | | Domestic. |
| 161 | Railroad School | do | 1891 | Bored, 7-inch | 1,527 | 1,427 | 118 | do | 180 | 25 | | Do. |
| 162 | D. Mulvahill | do | 1891 | do | 1,470 | 1,439 | 61 | do | 115 | 22 | | Do. |
| 163 | R. P. Lauretzen | do | | do | 1,550 | 1,474 | 106 | do | | | | Do. |
| 164 | | Sec. 4, T. 2 S., R. 3 W. | | do | 1,430 | | | do | | | | Do. |
| 165 | —— De Garmo | Sec. 8, T. 2 S., R. 3 W. | | do | 1,575 | 1,485 | 164 | Wind | | | | Do. |
| 166 | Smiley Brothers | Sec. 4, T. 2 S., R. 3 W. | | Dug, 7 by 7 foot | 1,347 | 1,330 | 23 | Centrifugal; gas | | | .50 | Irrigation. |
| 277 | L. F. Cram | Sec. 3, T. 1 S., R. 3 W. | 1895 | Bored, 12-inch | 1,305 | 1,189 | 147 | Wind | 1,000 | 100 | Small. | Domestic; irrigation. |
| 278 | C. C. Tyler | Sec. 2, T. 1 S., R. 3 W. | 1900 | Dug, 4 by 5 foot | 1,305 | | | | | | | |
| 279 | John McBride | Sec. 6, T. 1 S., R. 2 W. | 1900 | Dug, 4 by 4 foot | 1,650 | 1,636 | 65 | Centrifugal; gas | 500 | 400 | | Irrigation; domestic. |
| 280 | do | do | 1894 | Hydraulic, 4 by 6 foot | 1,654 | 1,654 | 130 | Tunnel, 130-foot, flows | 250 | | .02 | Irrigation. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 281 | Cram Brothers | Sec. 2, T. 1 S., R. 3 W | 1899 | Dug, 4 by 4 foot | 1,600 | 1,485 | 120 | | 300 | | | |
| 282 | E. Highland Orange Co. | Sec. 35, T. 1 N., R. 3 W | 1900 | Bored, 12-inch<br>Bored, 10-inch | 1,630 | 1,610 | 280<br>140 | Tunnel, flows | 1,680 | | .26 | Domestic; irrigation. |
| 283 | do | do | 1900 | Dug, 4 by 4 foot; bored, 10-inch. | 1,680 | 1,666 | | | | | | |
| 284 | W. M. Bristol | Sec. 34, T. 1 N., R. 3 W | 1899 | Dug, 5 by 5 foot | 1,650 | 1,634 | 50 | Cylinder pump; gas | | 1,250 | .30 | Irrigation. |
| 285 | Highland Domestic Water Co. | Sec. 27, T. 1 N., R. 3 W | 1899 | Dug, 7 by 9 foot | 1,440 | 1,411 | 65 | 2 cylinder pumps; 2 gas engines. | | [a] 1,500 | 1.10 | Domestic. |
| 286 | Highland Well Co | Sec 28, T. 1 N., R. 3 W | 1899 | Dug, 8 by 5 foot | 1,431 | 1,415 | 46 | Cylinder pump; gas | | | .68 | Irrigation. |
| 287 | J. C. Weeks | Sec. 3, T. 1 S., R. 3 W | 1900 | Dug, 4 by 4 foot; bored, 12-inch. | 1,295 | 1,181 | (b) | | | | | |
| 288 | H. S. Stroven | do | 1898 | Bored, 10-inch | 1,253 | 1,173 | 165 | Cylinder pump; gas | 400 | 1,160 | .40 | Irrigation; domestic. |
| 289 | N. Sutherland | Sec. 4, T. 1 S., R. 3 W | 1898 | Dug; bored, 12-inch. | 1,227 | 1,160 | 78 | | | | | Not used. |
| 290 | Pattee & Nye | Sec. 5, T. 1 S., R. 3 W | 1900 | Dug, 6 by 8 foot<br>Bored, 10-inch | 1,200 | 1,150 | 50<br>100 | Rotary pump; steam | | | .60 | Irrigation. |
| 291 | G. J. Fowler | do | 1899 | Dug, 5-foot | 1,180 | 1,127 | 55 | Hand | 50 | 17 | | Domestic. |
| 292 | R. F. Cunningham | do | 1890 | Dug, 6-foot | 1,160 | 1,120 | 43 | Centrifugal; steam | 150 | 1,450 | .80 | Irrigation. |
| 293 | do | do | 1899 | Bored, 7-inch | 1,147 | 1,103 | 36 | Hand | 160 | 15 | | Domestic. |
| 294 | do | Sec. 31, T. 1 N., R. 3 W | 1900 | Dug, 5 by 5 foot<br>Bored, 10-inch | 1,260 | 1,226 | 135<br>90 | Steam | | | 1.04 | Irrigation. |
| 295 | Redlands Water Co | Sec. 35, T. 1 S., R. 3 W | 1899 | do | 1,568 | | | | | | | |
| 297 | C. K. Matteson | Sec. 7, T. 1 S., R. 3 W | 1884 | Dug | 1,103 | 1,080 | 25 | Hand | 30 | 4 | | Domestic. |
| 298 | do | do | 1894 | Bored, 10-inch | 1,103 | 1,083 | 44 | Centrifugal; gas | 175 | 510 | .60 | Irrigation. |
| 299 | Geo. Gustave | do | 1900 | Dug, 4 by 6 foot | 1,101 | 1,082 | 25 | do | 50 | | .30 | Irrigation; domestic. |
| 300 | do | do | | Dug, 3 by 4 foot | 1,103 | 1,085 | 19 | | | | | |
| 301 | Mrs. H. Taylor | do | | Dug, 3-foot | 1,102 | 1,080 | 25 | Centrifugal; steam | | | | Irrigation. |
| 302 | C. Wiltshire | Sec. 6, T. 1 S., R. 3 W | 1895 | Driven, 2-inch | 1,102 | 1,080 | 27 | Hand | | 25 | | Domestic. |
| 303 | Mrs. H. Taylor | Sec. 7, T. 1 S., R. 3 W | 1891 | Bored, 3-inch | 1,101 | | 235 | do | 300 | | 3.00 | Domestic; irrigation. |
| 304 | W. F. Somers | do | 1900 | Bored, 10-inch | 1,101 | 1,081 | (c) | | | | | |
| 305 | Mrs. Golden | Sec. 12, T. 1 S., R. 4 W | 1900 | do | 1,099 | 1,099 | | Artesian | | | | Irrigation. |
| 306 | do | do | 1898 | Bored, 8-inch | 1,102 | 1,102 | 744 | do | 1,600 | | [d] 1.10 | Domestic; irrigation. |

[a] Two engines. [b] Unfinished. [c] Not completed. [d] December, 1898.

*Wells in Redlands quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 307 | W. F. Somers | Sec. 7, T. 1 S., R. 3 W | 1895 | Dug | 1,098 | 1,080 | 20 | Hand | $20 | | 7.00 | Domestic. |
| 308 | do | do | 1899 | Dug, 3 by 3 foot | 1,097 | 1,079 | 20 | do | 20 | | 4.00 | Stock. |
| 309 | John Kaus | do | 1899 | Bored, 8-inch | 1,103 | 1,085 | 20 | Steam | 40 | | | Domestic. |
| 310 | F. P. Sargent | Sec. 13, T. 1 S., R. 4 W | 1894 | Driven, 2-inch | 1,096 | 1,084 | 24 | Hand | 15 | $10 | | Do. |
| 311 | S. E. Fitzhugh | Sec. 12, T. 1 S., R. 4 W | 1888 | Bored, 3-inch | 1,080 | 1,073 | 234 | do | 500 | 6 | | Do. |
| 312 | do | do | 1885 | Bored, 7-inch | 1,081 | 1,064 | 20 | do | 35 | 6 | | Do. |
| 313 | W. Borne | Sec. 7, T. 1 S., R. 3 W | | Dug, 3½ by 3½ foot | 1,103 | | | do | | | | Do. |
| 314 | Geo. Covalt | do | 1899 | Bored, 7-inch | 1,104 | 1,079 | 30 | do | | 4 | | Do. |
| 315 | W. F. Somers | Sec. 1, T. 1 S., R. 4 W | | Bored, 3-inch | 1,099 | 1,095 | 283 | do | | | | Do. |
| 316 | W. K. Bledsoe | do | | Dug, 4½-foot | 1,103 | 1,086 | 21 | do | 25 | 3 | | Do. |
| 317 | T. J. West | do | 1900 | Dug, 5-foot | 1,093 | 1,090 | 20 | Centrifugal; steam | 400 | 820 | 1.30 | Irrigation. |
| 318 | S. Van Leuven | Sec. 6, T. 1 S., R. 3 W | 1883 | Bored, 3-inch | 1,104 | 1,105 | 309 | Wind | | | | Irrigation; domestic. |
| 319 | Ed. Dailey | do | 1890 | do | 1,102 | 1,091 | 325 | Hand | | | | Domestic. |
| 320 | do | do | 1890 | do | 1,106 | 1,105 | 320 | | | | | Not used. |
| 321 | do | do | 1885 | do | 1,103 | 1,093 | 350 | Hand | | | | Domestic. |
| 322 | W. A. Brouse | do | 1899 | Dug | 1,104 | 1,084 | 22 | do | 25 | 5 | | Do. |
| 323 | do | do | 1884 | Dug, 5-foot | 1,104 | 1,084 | 26 | Centrifugal; steam | 150 | 630 | .50 | Irrigation. |
| 324 | do | do | 1893 | do | 1,106 | 1,086 | 25 | do | 150 | 620 | .50 | Do. |
| 325 | Herman Smith | do | 1899 | Dug, 4 by 4 foot | 1,109 | 1,084 | 27 | Hand | 100 | 12 | | Domestic. |
| 326 | J. Friedmann | do | 1885 | Dug, 6-foot | 1,107 | 1,090 | 22 | Centrifugal; steam | 130 | 485 | 1.00 | Irrigation; domestic. |
| 327 | J. Dunlap | Sec. 1, T. 1 S., R. 4 W | | Bored, 3-inch | 1,102 | 1,102 | 185 | Artesian | | | .18 | Domestic. |
| 328 | H. C. Keller | do | 1880 | Bored, 2-inch | 1,104 | 1,104 | 169 | do | | | .02 | Do. |
| 329 | A. Roberts | Sec. 6, T. 1 S., R. 3 W | 1892 | Bored, 3-inch | 1,105 | 1,105 | 231 | do | 426 | | .005 | Do. |
| 330 | Warm Creek School | do | 1885 | Bored, 2-inch | 1,106 | 1,101 | 150 | Hand | 175 | | | Do. |
| 331 | W. L. McKenzie | Sec. 1, T. 1 S., R. 4 W | 1875 | do | 1,105 | 1,105 | 320 | Artesian | | | .01 | Irrigation; domestic. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 332 | Wm. Shay | Sec. 31, T. 1 N., R. 3 W. | 1890 | Bored, 3-inch | 1,103 | 1,103 | 150 | do | 300 | | .06 | Domestic. |
| 333 | Wm. Clyde | Sec. 6, T. 1 S., R. 3 W. | 1889 | Bored, 2-inch | 1,106 | 1,106 | 146 | do | 150 | | .03 | Irrigation; domestic. |
| 334 | Riverside Water Co | Sec. 1, T. 1 S., R. 4 W. | 1898 | Bored, 10-inch | 1,086 | | 648 | do | | | | Irrigation. |
| 335 | do | do | 1898 | do | 1,088 | | 590 | do | 1,100 | | 1.20 | Do. |
| 336 | do | do | 1898 | Bored | 1,085 | | 381 | do | | | | Do. |
| 337 | do | do | | do | 1,084 | 1,084 | 440 | do | | | | Do. |
| 338 | Redlands Domestic Water Co. | Sec. 35, T. 1 S., R. 3 W. | 1899 | Bored, 10-inch (2) | 1,640 | 1,550 | 243<br>400 | Centrifugal; electric | 650 | | .80 | Domestic. |
| 339 | Thos. Shay | Sec. 31, T. 1 N., R. 3 W. | 1888 | Bored, 7-inch | 1,103 | 1,089 | 20 | Hand | 30 | 5 | | Do. |
| 340 | do | do | 1895 | Dug, 4 by 4 foot<br>Bored, 8-inch | 1,098 | | 80 | Cylinder pump; gas | 300 | 1,680 | .50 | Irrigation. |
| 341 | R. T. Clyde | Sec. 6, T. 1 S., R. 3 W. | 1880 | Bored, 2-inch | 1,105 | 1,105 | 133 | Artesian | 100 | | | Domestic; irrigation. |
| 342 | F. L. Talmadge | do | 1880 | do | 1,106 | 1,106 | 135 | Hand | 100 | 5 | | Domestic. |
| 343 | Talmadge & Haws | do | 1897 | Bored, 10-inch | 1,140 | 1,132 | 425 | Centrifugal; gas | 850 | 986 | 2.00 | Irrigation. |
| 344 | Mrs. Haws | do | 1898 | Bored, 2-inch | 1,125 | 1,125 | 100 | Hand | 75 | 3 | | Domestic. |
| 345 | John D. Clark | Sec. 31, T. 1 N., R. 3 W. | 1899 | Bored, 3-inch | 1,130 | 1,130 | 125 | Artesian | 120 | | .02 | Domestic; irrigation. |
| 346 | do | do | 1892 | do | 1,132 | 1,132 | 50 | do | 45 | | | Do. |
| 347 | D. R. Seely | Sec. 33, T. 1 N., R. 3 W. | 1890 | do | 1,250 | 1,176 | 124 | Wind | | | .005 | Domestic. |
| 348 | do | do | 1899 | Bored, 12-inch | 1,285 | 1,110 | 195 | Cylinder pump; gas | | | | Irrigation. |
| 349 | W. D. Stevens | Sec. 5, T. 1 S., R. 3 W. | 1894 | Dug, 8-foot<br>Bored, 10-inch | 1,180 | 1,130 | 40<br>60 | Centrifugal; gas | | 815 | .60 | Irrigation; domestic. |
| 350 | Jane C. Goodman | Sec. 6, T. 1 S., R. 3 W. | 1894 | Bored, 3-inch | 1,140 | 1,128 | 284 | Wind | 625 | 108 | .001 | Do. |
| 351 | Jas. Roddick | Sec. 5, T. 1 S., R. 3 W. | 1898 | Dug, 4-foot | 1,143 | 1,114 | 30 | Centrifugal; gas | | 250 | .20 | Do. |
| 352 | Saml. Roddick | Sec. 6, T. 1 S., R. 3 W. | 1899 | Driven, 1¼-inch | 1,139 | 1,117 | 27 | Hand | 7 | 10 | | Domestic. |
| 353 | W. F. Talmadge | do | 1885 | Bored, 7-inch | 1,148 | 1,132 | 30 | Wind | | 80 | .001 | Domestic; irrigation. |
| 354 | do | do | 1891 | Bored, 3-inch | 1,146 | 1,131 | 41 | Hand | | 6 | | Domestic. |
| 355 | A. Downey | do | 1899 | Driven, 1¼-inch | 1,143 | 1,131 | 21 | do | 4 | 3 | | Do. |
| 356 | F. A. Haws | do | 1899 | Driven, 1¼-inch | 1,130 | 1,120 | 26 | do | 5 | 5 | | Do. |
| 357 | E. S. Haws | do | 1899 | do | 1,130 | 1,120 | 20 | do | 5 | 5 | | Do. |
| 358 | Mrs. M. C. Haws | do | 1895 | Bored, 3-inch | 1,125 | 1,125 | 125 | Artesian | 250 | | | Do. |
| 359 | Walter Shay | Sec. 31, T. 1 N., R. 3 W. | | Bored, 7-inch | 1,110 | | | Hand | | | | Do. |

*Wells in Redlands quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 360 | Kohl Bros. | Sec. 32, T. 1 N., R. 3 W. | 1890 | Bored, 6-inch | 1,147 | 1,129 | 60 | Wind | | | .001 | Domestic. |
| 361 | H. D. Rabel | Sec. 31, T. 1 N., R. 3 W. | 1896 | Bored, 2-inch | 1,140 | 1,140 | 68 | Artesian | $40 | | | Do. |
| 362 | do | do | 1898 | Bored, 3-inch | 1,142 | 1,142 | 86 | do | 70 | | .01 | Do. |
| 363 | do | do | 1898 | do | 1,139 | 1,139 | 44 | do | 30 | | .25 | Do. |
| 364 | do | do | | do | 1,137 | 1,137 | 72 | do | 70 | | .005 | Do. |
| 366 | D. J. Carpenter | Sec. 24, T. 1 N., R. 4 W. | 1900 | Dug, 6 by 9 foot | 1,470 | 1,447 | 25 | | | | | |
| 367 | | | | | 1,475 | 1,475 | 71 | | | | .06 | |
| 368 | | | | | 1,474 | 1,474 | 123 | | | | .10 | |
| 369 | | | | | 1,474 | 1,474 | 193 | | | | .08 | |
| 370 | D. J. Carpenter & Co. | do | | Bored, 7-inch | 1,476 | 1,476 | 184 | Centrifugal; gas | | $1,100 | .14 | Irrigation. |
| 371 | | | | | 1,473 | 1,473 | | | | | .10 | |
| 372 | | | | | 1,473 | 1,473 | 127 | | | | .10 | |
| 373 | | | | | 1,473 | 1,473 | 167 | | | | .06 | |
| 374 | W. J. Lindville | Sec. 30, T. 1 N., R. 3 W. | 1899 | Bored, 10-inch | 1,270 | 1,140 | 368 | Cylinder pump; gas | | 3,000 | .36 | Do. |
| 375 | Mrs. R. L. Burcham | Sec. 31, T. 1 N., R. 3 W. | 1899 | Bored, 12-inch | 1,224 | 1,154 | 460 | do | 1,200 | 2,250 | .70 | Do. |
| 376 | E. K. Henderson | Sec. 30, T. 1 N., R. 3 W. | 1899 | Bored, 3-inch | 1,233 | 1,133 | 134 | Wind | 150 | | | Domestic. |
| 377 | Jas. McCafferty | Sec. 31, T. 1 N., R. 3 W. | 1896 | Bored, 7-inch | 1,225 | | 80–100 | Cylinder pump; gas | | 2,500 | .40 | Irrigation; domestic. |
| 378 | J. D. Clark | do | 1897 | Bored, 11-inch | 1,170 | | 106 | do | | | .40 | Irrigation. |
| 379 | P. W. Gray | do | 1893 | Bored, 7-inch | 1,170 | 1,120 | 139 | Wind | | | .03 | Domestic; irrigation. |
| 381 | John Lin Foster | Sec. 32, T. 1 N., R. 3 W. | 1894 | Bored, 10-inch | 1,220 | | 95 | do | 600 | (a) | .003 | Do. |
| 382 | P. H. Gleason | do | 1900 | Dug, 4 by 4 foot | 1,250 | 1,175 | 78 | do | | | .002 | Do. |
| 383 | E. L. Cumbl | do | 1897 | do | 1,128 | 1,091 | 38 | Hand | 50 | | | Domestic. |
| 384 | A. C. Pierce | do | 1898 | do | 1,210 | 1,150 | 62 | Wind | 120 | 140 | .005 | Domestic; irrigation. |
| 385 | Kohl Bros. | do | 1898 | Bored, 10-inch | 1,148 | 1,136 | 300 | Centrifugal; gas | 600 | 700 | 1.00 | Do. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 386 | State of California Hospital for Insane. | Sec. 5, T. 1 S., R. 3 W. | ..... | ....do | 1,110 | 1,078 | 85 | Centrifugal; electricity | ..... | ..... | 1.60 | Irrigation. |
| 387 | Geo. Fowler | Sec. 32, T. 1 N., R. 3 W. | 1888 | Dug, 3 by 3 foot | 1,165 | 1,137 | 29 | Hand | ..... | ..... | ..... | Domestic. |
| 388 | C. D. Fowler | Sec. 5, T. 1 S., R. 3 W. | 1895 | Dug, 4 foot | 1,168 | 1,135 | 34 | ....do | ..... | ..... | ..... | Do. |
| 389 | J. Bagwell | Sec. 32, T. 1 N., R. 3 W. | 1900 | Dug, 4 by 4 foot; bored, 12-inch. | 1,230 | 1,117 | 153 | Cylinder pump; gas | ..... | ..... | .20 | Irrigation. |
| 390 | A. A. Boyd | ....do | 1896 | Dug; bored, 7-inch | 1,290 | 1,138 | 202 | ....do | ..... | ..... | .22 | Irrigation; domestic. |
| 391 | Gage Canal Co | Sec. 13, T. 1 S., R. 4 W. | 1891 | Bored, 10-inch | 1,058 | 1,058 | 168 | Artesian | ..... | ..... | [b]4.306 | Irrigation. |
| 392 | ....do | ....do | 1891 | ....do | 1,059 | 1,059 | 166 | ....do | ..... | ..... | [b]1.521 | Do. |
| 394 | ....do | ....do | 1891 | ....do | 1,063 | 1,063 | 123 | ....do | ..... | ..... | [b]1.712 | Do. |
| 395 | ....do | ....do | 1891 | ....do | 1,066 | 1,066 | 125 | ....do | ..... | ..... | [b].594 | Do. |
| 396 | ....do | Sec. 18, T. 1 S., R. 3 W. | 1887 | ....do | 1,062 | 1,062 | 144 | ....do | ..... | ..... | [b]2.131 | Do. |
| 397 | ....do | ....do | 1887 | Bored, 10½-inch | 1,064 | 1,064 | 140 | ....do | ..... | ..... | [b]1.011 | Do. |
| 398 | ....do | ....do | 1888 | Bored, 10-inch | 1,075 | 1,075 | 138 | ....do | ..... | ..... | [b].605 | Do. |
| 399 | ....do | ....do | 1888 | ....do | 1,075 | 1,075 | 106 | ....do | ..... | ..... | [b].188 | Do. |
| 400 | ....do | ....do | 1888 | ....do | 1,074 | 1,074 | 130 | ....do | ..... | ..... | [b].563 | Do. |
| 401 | ....do | ....do | 1888 | ....do | 1,071 | 1,071 | 146 | ....do | ..... | ..... | [b]2.212 | Do. |
| 402 | ....do | ....do | 1888 | ....do | 1,065 | 1,065 | 116 | ....do | ..... | ..... | [b]3.176 | Do. |
| 403 | ....do | ....do | 1888 | ....do | 1,064 | 1,064 | 134 | ....do | ..... | ..... | [b]1.424 | Do. |
| 404 | ....do | ....do | 1888 | ....do | 1,061 | 1,061 | 116 | ....do | ..... | ..... | [b].594 | Do. |
| 405 | ....do | Sec. 13, T. 1 S., R. 4 W. | 1887 | ....do | 1,057 | 1,057 | 147 | ....do | ..... | ..... | [b]2.254 | Do. |
| 406 | ....do | ....do | 1887 | ....do | 1,058 | 1,058 | 122 | ....do | ..... | ..... | [b]1.026 | Do. |
| 407 | ....do | ....do | 1892 | ....do | 1,059 | 1,059 | 115 | ....do | ..... | ..... | [b].484 | Do. |
| 408 | ....do | ....do | 1892 | Bored, 10½-inch | 1,053 | 1,053 | 169 | ....do | ..... | ..... | [c]8.105 | Do. |
| 409 | ....do | Sec. 18, T. 1 S., R. 3 W. | 1886 | Bored, 7-inch | 1,077 | ..... | 127 | ([d]) | ..... | ..... | [c].286 | Do. |
| 410 | ....do | ....do | 1886 | ....do | 1,076 | ..... | 127 | ([d]) | ..... | ..... | [c].302 | Do. |
| 411 | ....do | ....do | 1886 | ....do | 1,077 | ..... | 125 | ([d]) | ..... | ..... | [c].270 | Do. |
| 412 | ....do | ....do | 1886 | ....do | 1,077 | ..... | 125 | ([d]) | ..... | ..... | [c].416 | Do. |

[a] Included in cost of well.
[b] Flow of wells Nos. 391 to 412 is given for October, 1892.
[c] December, 1898.
[d] Wells 409 to 412 are pumped by 15-horsepower gas engine and centrifugal pump, raising 2 second-feet of water. These were artesian wells when sunk.

*Wells in San Bernardino quadrangle.*

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 1 | Riverside Water Co | Sec. 27, T. 1 S., R. 4 W | 1887 | 11-inch pipe | 1,014 | 1,014 | 115 | Artesian | | | [a] 0.329 | Domestic. |
| 2 | do | do | | do | 1,015 | 1,015 | 118 | do | | | [b] .284 | Do. |
| 3 | do | do | | do | 1,015 | 1,015 | 113 | do | | | [b] .117 | Do. |
| 4 | do | do | | do | 1,016 | 1,016 | 111 | do | | | [b] .153 | Do. |
| 5 | do | do | | do | 1,014 | 1,014 | 112 | do | | | [b] .117 | Do. |
| 6 | do | do | | do | 1,016 | 1,016 | 120 | do | | | [b] .150 | Do. |
| 7 | do | do | 1888 | 7-inch pipe | 1,013 | 1,013 | 128 | do | $400 | | [b] .150 | Do. |
| 8 | do | do | 1888 | 9-inch pipe | 1,016 | 1,016 | 125 | do | 525 | | [b] .096 | Do. |
| 9 | do | do | 1888 | 9.5-inch pipe | 1,018 | 1,018 | 123 | do | 500 | | | Do. |
| 10 | do | do | 1888 | 9-inch pipe | 1,017 | 1,017 | 127 | do | 550 | | | Do. |
| 11 | do | do | 1888 | do | 1,021 | 1,021 | 201 | do | 800 | | [b] .125 | Do. |
| 12 | do | do | | do | 1,020 | 1,020 | 141 | do | 650 | | | Do. |
| 13 | do | do | 1889 | do | 1,015 | 1,015 | 127 | do | 525 | | | Do. |
| 14 | do | do | 1889 | do | 1,014 | 1,014 | 125 | do | 550 | | [b] .068 | Do. |
| 15 | do | Sec. 22, T. 1 S., R. 4 W | 1889 | 11-inch pipe | 964 | 964 | 86 | do | 480 | | [c] .442 | Irrigation. |
| 16 | do | do | 1889 | 9-inch pipe | 981 | 981 | 123 | do | | | [c] .083 | Do. |
| 17 | do | do | 1889 | do | 955 | 955 | 81 | do | | | [c] .900 | Do. |
| 18 | do | do | 1889 | do | 955 | 955 | 92 | do | | | [c] .361 | Do. |
| 19 | do | Sec. 16, T. 1 S., R. 4 W | 1889 | do | 972 | 972 | 225 | do | | | [b] .158 | Do. |
| [d] 20 | do | do | 1889 | 7-inch pipe | 978 | 978 | 75 | | | | | |
| [d] 21 | do | do | 1891 | do | 971 | 971 | 175 | | | | | |
| 22 | do | do | 1889 | 9-inch pipe | 973 | 973 | 55 | Artesian | | | .173 | Do. |
| 23 | do | do | 1889 | do | 974 | 974 | 121 | do | | | .355 | Do. |
| 24 | do | Sec. 22, T. 1 S., R. 4 W | 1889 | 7-inch pipe | 989 | 989 | 192 | do | | | [c] .175 | Do. |
| 25 | do | do | 1889 | 9-inch pipe | 968 | 968 | 81 | do | | | [c] .207 | Do. |
| 26 | do | do | 1889 | do | 967 | 967 | 83 | do | | | [c] .301 | Do. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | do | do | 1889 | do | 981 | 981 | 103 | do | | | c.952 | Do. |
| 28 | do | do | 1889 | do | 970 | 970 | 83 | do | | | e.273 | Do. |
| 29 | do | do | 1889 | do | 979 | 979 | 101 | do | | | e.640 | Do. |
| 30 | do | do | 1890 | do | 978 | 978 | 97 | do | | | e1.417 | Do. |
| 31 | do | do | 1890 | do | 980 | 980 | 165 | do | | | e.569 | Do. |
| 32 | do | do | 1890 | do | 979 | 979 | 165 | do | | | e.616 | Do. |
| 33 | do | Sec. 27, T. 1 S., R. 4 W. | 1891 | 9.5-inch pipe | 1,012 | 1,012 | 330 | do | | | b3.28 | Domestic. |
| 34 | do | do | 1891 | do | 1,012 | 1,012 | 326 | do | | | | Do. |
| 35 | do | Sec. 22, T. 1 S., R. 4 W. | | do | 977 | 977 | 82 | do | 255 | | f.860 | Irrigation. |
| 37 | do | Sec. 27, T. 1 S., R. 4 W. | | do | 1,012 | 1,012 | 249 | do | | | | Domestic. |
| 38 | do | Sec. 1, T. 1 S., R. 4 W. | 1892 | 7-inch pipe | 1,083 | 1,083 | 187 | do | 662 | | g.027 | Irrigation. |
| 39 | do | do | 1893 | 9.5-inch pipe | 1,083 | 1,083 | 396 | do | | | g.714 | Do. |
| 42 | do | Sec. 27, T. 1 S., R. 4 W. | 1893 | do | 1,011 | 1,011 | 344 | do | | | | Domestic. |
| 43 | do | Sec. 1, T. 1 S., R. 4 W. | 1894 | do | 1,086 | 1,086 | 420 | do | 630 | | h1.452 | Irrigation. |
| 44 | do | Sec. 22, T. 1 S., R. 4 W. | 1896 | 9-inch pipe | 979 | 979 | 133 | do | 250 | | e.971 | Do. |
| 45 | do | do | 1896 | do | 979 | 979 | 173 | do | 420 | | | Do. |
| 47 | do | Sec. 3, T. 1 S., R. 4 W. | 1898 | do | 1,025 | 1,025 | 168 | do | 500 | | | Do. |
| 51 | do | Sec. 22, T. 1 S., R. 4 W. | | 8-inch pipe | 954 | 954 | 78 | do | | | | Do. |
| 52 | do | do | | do | 955 | 955 | 94 | do | | | | Do. |
| 53 | do | do | 1898 | do | 956 | 956 | 68 | do | | | | Do. |
| 54 | do | do | 1898 | do | 957 | 957 | 68 | do | | | | Do. |
| 55 | do | do | 1898 | 7-inch pipe | 958 | 958 | 92 | do | | | | Do. |
| 56 | do | do | 1898 | do | 959 | 959 | 75 | do | | | | Do. |
| 57 | do | do | 1898 | 8-inch pipe | 960 | 960 | 92 | do | 128 | | | Do. |
| 58 | do | do | 1898 | 7-inch pipe | 960 | 960 | 87 | do | 157 | | i.456 | Do. |
| 59 | do | do | 1898 | 8-inch pipe | 961 | 961 | 85 | do | 138 | | i.622 | Do. |
| 60 | do | do | 1898 | 7-inch pipe | 961 | 961 | 93 | do | 173 | | i.456 | Do. |
| 61 | do | do | | 8-inch pipe | 952 | 952 | | do | | | | Do. |
| 62 | do | Sec. 15, T. 1 S., R. 4 W. | 1898 | do | 985 | 985 | 183 | do | | | i.34 | Do. |
| 65 | do | Sec. 2, T. 1 S., R. 4 W. | 1900 | 10-inch pipe | 1,040 | 1,040 | 540 | do | | | 2.89 | Do. |
| 66 | do | do | 1900 | do | 1,035 | 1,035 | 580 | do | | | 2.606 | Do. |
| 67 | Wm. Roach | Sec. 6, T. 2 S., R. 4 W. | 1889 | 7-inch pipe | 904 | 852 | 130 | 10 wind | 200 | $160 | .015 | Irrigation; domestic. |

a 1890. b 1891. c 1896. d Well filled and covered with sand from flood and lost. e 1896. f 1892. g 1900. h 1894. i 1898.

*Wells in San Bernardino quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 68 | Wm. Roach | Sec. 6, T. 2 S., R. 4 W. | 1875 | 7-inch pipe | 905 | 852 | 70 | 12 wind | $105 | $130 | .006 | Irrigation. |
| 69 | Mrs. Douglas | do | 1893 | do | 895 | 835 | 112 | Wind | | | .015 | Irrigation; domestic. |
| 70 | Louise Peña | Sec. 12, T. 2 S., R. 5 W. | 1888 | Dug, 3 by 4 foot | 835 | 815 | 22 | do | | 110 | Small. | Domestic. |
| 71 | P. Evans | do | 1900 | 10-inch pipe | 840 | 840 | 400 | Artesian | | | 1.000 | Irrigation. |
| 72 | P. Baca | do | 1899 | Dug, 3 by 3 foot | 852 | 832 | 22 | Hand | 20 | | Small. | Domestic. |
| 73 | W. L. Zader | Sec. 29, T. 1 S., R. 4 W. | 1894 | Dug, 3-foot diameter. | 980 | 930 | 52 | 8 wind | 40 | 35 | Small. | Do. |
| 74 | D. Jones | do | 1888 | do | 980 | | 70 | Wind | 100 | 200 | | |
| 75 | T. J. Smith | Sec. 30, T. 1 S., R. 4 W. | 1890 | do | 974 | | 38 | do | | | | |
| 76 | Mrs. B. R. Atkins | do | 1897 | do | 980 | 938 | 59 | 9 wind | | 500 | Small. | Do. |
| 77 | | do | | Dug, 3 by 3 foot | 886 | 871 | 17 | Hand | | | | Do. |
| 78 | M. G. Soares | do | | do | 875 | 871 | 6 | do | | | | Do. |
| 79 | Thos. McGraw | Sec. 35, T. 1 S., R. 5 W. | 1895 | Dug, 4 by 4 foot | 875 | 837 | 39 | do | 70 | 14 | Small. | Do. |
| 80 | Henry Carson | Sec. 10, T. 2 S., R. 5 W. | 1900 | Dug, 3-foot diameter. | 831 | 784 | 49 | | 40 | 40 | | Do. |
| 81 | Dan Baker | do | 1885 | 6-inch pipe | 826 | 786 | 60 | Hand | | 20 | | Do. |
| 82 | Mrs. Burgess | Sec. 34, T. 1 S., R. 5 W. | | Dug, 4 by 4 foot | 988 | 848 | 150 | Wind | | | | Not used. |
| 83 | T. Pulley | Sec. 10, T. 2 S., R. 5 W. | (a) | Bored, 20-inch | 881 | 808 | 89 | | | | | |
| 84 | Mrs. L. M. Henry | do | 1898 | 6-inch pipe | 895 | 787 | 128 | Wind | | | | Irrigation; domestic. |
| 85 | T. Pulley | do | 1896 | Dug, 3-foot diameter. | 850 | 780 | 72 | do | 50 | 120 | | Do. |
| 86 | John Miller | do | 1900 | do | 866 | 800 | 69 | do | 40 | | | Domestic. |
| 87 | Ed. Bridson | Sec. 15, T. 2 S., R. 5 W. | 1898 | 7-inch pipe | 840 | 780 | 100 | 10 wind | 150 | 150 | | Domestic; stock. |
| 88 | J. Rogerson | do | | Dug, 4 by 4 foot | 830 | 794 | 37 | Hand | | | | Domestic. |
| 89 | Mrs. A. Parks | do | | 7-inch pipe | 810 | 793 | 28 | Wind | | | | Domestic; stock. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 90 | H. C. Parks | Sec. 9, T. 2 S., R. 5 W. | 1887 | Dug, 3-foot diameter. | 850 | 784 | 75 | do | 325 | 180 | | Do. |
| 91 | Scott La Rue | do | 1900 | do | 845 | 742 | 107 | do | 100 | 285 | | Do. |
| 92 | Emuel Spooner | Sec. 8, T. 2 S., R. 5 W. | 1896 | Dug, 4 by 4 foot | 850 | 750 | 105 | do | 115 | | | Do. |
| 93 | do | do | 1900 | do | 850 | 750 | 107 | | 125 | | | |
| 94 | W. J. Thomas | Sec. 7, T. 2 S., R. 5 W. | 1900 | Dug, 4½ by 4 foot | 847 | 817 | 35 | | 70 | | | Domestic. |
| 95 | E. Thomas | do | 1899 | Dug, 3 by 3 foot | 850 | 814 | 41 | Wind | 75 | 150 | | Irrigation. |
| 96 | do | do | 1894 | do | 841 | 817 | 26 | Hand | 40 | | | Domestic. |
| 97 | Mrs. H. M. Thurber | Sec. 12, T. 2 S., R. 6 W. | 1896 | Dug, 5-foot diameter. | 800 | 782 | 28 | Wind | | | | Irrigation; domestic. |
| 98 | F. D. Lewis | Sec. 13, T. 2 S., R. 6 W. | | Dug, 4 by 4 foot | 795 | 775 | 40 | 10 wind | | | | Domestic. |
| 99 | | Sec. 12, T. 2 S., R. 6 W. | | do | 789 | 770 | 31 | do | | | | Do. |
| 100 | John Parkhurst | do | 1898 | Dug, 6-foot diameter. | 818 | 807 | 13.5 | 12 wind | 100 | 135 | | Do. |
| 101 | J. R. Johnston | Sec. 6, T. 2 S., R. 5 W. | | Pipe line | | | | | | | | Domestic; stock. |
| 102 | I. McBride | Sec. 12, T. 2 S., R. 6 W. | 1892 | Dug, 3.5 by 3.5 foot | 813 | 787 | 55 | 8 wind | 80 | 100 | Small. | Domestic. |
| 103 | Milo Gilbert | Sec. 24, T. 1 S., R. 4 W. | 1900 | 7-inch pipe | 1,004 | 864 | 220 | 12 wind | | | | |
| 104 | Riverside Trust Co. | do | 1898 | 10-inch pipe | 1,077 | 1,077 | 506 | Artesian | | | 1.600 | Irrigation. |
| 105 | do | do | 1898 | do | 1,071 | 1,071 | 531 | do | | | 1.200 | Do. |
| 106 | do | do | 1898 | do | 1,065 | 1,065 | 517 | do | | | 1.400 | Do. |
| 107 | do | Sec. 23, T. 1 S., R. 4 W. | 1899 | do | 1,045 | 1,045 | 675 | do | | | 1.500 | Do. |
| 108 | do | Sec. 24, T. 1 S., R. 4 W. | 1899 | do | 1,076 | 1,076 | 568 | do | | | 2.040 | Do. |
| 109 | do | Sec. 26, T. 1 S., R. 4 W. | 1899 | do | 1,019 | 1,019 | 554 | do | | | .400 | Do. |
| 110 | do | Sec. 13, T. 1 S., R. 4 W. | 1899 | do | 1,052 | 1,052 | 580 | do | | | | Do. |
| 111 | do | do | 1899 | do | 1,061 | 1,061 | 537 | do | | | 2.600 | Do. |
| 112 | do | do | 1899 | do | 1,066 | 1,066 | 577 | do | | | 1.200 | Do. |
| 113 | do | do | 1899 | do | 1,069 | 1,069 | 505 | do | | | 1.040 | Do. |
| 114 | do | do | 1900 | do | 1,079 | 1,079 | 478 | do | | | 3.000 | Do. |
| 115 | Gage Canal Co | Sec. 26, T. 1 S., R. 4 W. | 1891 | do | 1,033 | 1,033 | 656 | do | | | .089 | Do. |
| 116 | do | do | 1891 | do | 1,034 | 1,034 | 534 | do | | | .956 | Do. |
| 117 | do | do | 1891 | do | 1,034 | 1,034 | 582 | do | | | .770 | Do. |
| 118 | do | do | 1891 | do | 1,034 | 1,034 | 482 | do | | | 1.026 | Do. |
| 119 | do | do | 1891 | 10½-inch pipe | 1,034 | 1,034 | 320 | do | | | .064 | Do. |
| 120 | do | do | 1891 | 10-inch pipe | 1,034 | 1,034 | 784 | do | | | 1.089 | Do. |

[a] Not finished.

*Wells in San Bernardino quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 121 | Gage Canal Co | Sec. 23, T. 1 S., R. 4 W. | 1888 | 10½-inch pipe | 1,036 | 1,036 | 196 | Artesian | | | .550 | Irrigation. |
| 122 | do | do | 1888 | do | 1,036 | 1,036 | 190 | do | | | .979 | Do. |
| 123 | do | do | 1889 | 10-inch pipe | 1,036 | 1,036 | 142 | do | | | .188 | Do. |
| 124 | do | do | 1889 | 10½-inch pipe | 1,036 | 1,036 | 148 | do | | | .121 | Do. |
| 125 | do | Sec. 24, T. 1 S., R. 4 W. | 1886 | 7-inch pipe | 1,037 | 1,037 | 141 | do | | | 2.330 | Do. |
| 126 | do | Sec. 13, T. 1 S., R. 4 W. | 1886 | do | 1,037 | 1,037 | 181 | do | | | 1.928 | Do. |
| 127 | do | do | 1891 | 10-inch pipe | 1,037 | 1,037 | 426 | do | | | 5.901 | Do. |
| 128 | do | do | 1891 | do | 1,037 | 1,037 | 472 | do | | | 1.874 | Do. |
| 129 | do | do | 1891 | do | 1,048 | 1,048 | 518 | do | | | 1.874 | Do. |
| 130 | do | do | 1891 | do | 1,049 | 1,049 | 338 | do | | | 1.264 | Do. |
| 131 | do | do | 1891 | do | 1,049 | 1,049 | 380 | do | | | .770 | Do. |
| 132 | do | do | 1891 | do | 1,049 | 1,049 | 386 | do | | | 1.424 | Do. |
| 133 | do | do | 1891 | do | 1,052 | 1,052 | 198 | do | | | 5.314 | Do. |
| 134 | do | do | 1891 | do | 1,057 | 1,057 | 124 | do | | | 1.299 | Do. |
| 135 | do | do | 1891 | do | 1,055 | 1,055 | 116 | do | | | 2.746 | Do. |
| 136 | do | do | 1891 | do | 1,057 | 1,057 | 134 | do | | | 5.668 | Do. |
| 155 | do | do | 1892 | do | 1,051 | 1,051 | 198 | do | | | 8.239 | Do. |
| 156 | do | do | 1892 | do | 1,046 | 1,046 | 192 | do | | | 8.315 | Do. |
| 157 | do | do | 1892 | 10½-inch pipe | 1,044 | 1,044 | 390 | do | | | 4.835 | Do. |
| 158 | do | do | 1892 | 10-inch pipe | 1,042 | 1,042 | 224 | do | | | 5.697 | Do. |
| 159 | do | do | 1885 | 7-inch pipe | 1,045 | | 128 | | | | 1.923 | Do. |
| 160 | do | do | 1885 | do | 1,045 | | 133 | | | | .473 | Do. |
| 161 | do | do | 1885 | do | 1,045 | | 133 | | | | 3.015 | Do. |
| 162 | do | do | 1885 | 5-inch pipe | 1,048 | | 139 | | | | 8.217 | Do. |
| 163 | do | do | 1885 | 7-inch pipe | 1,048 | | 211 | | | | 4.641 | Do. |
| 164 | do | do | 1885 | do | 1,046 | | 100 | | | | .579 | Do. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 169 | do | do | 1890 | 10-inch pipe | 1,037 | 1,037 | 300 | Artesian | | | 5.901 | Do. |
| 170 | Riverside Trust Co | Sec. 23, T. 1 S., R. 4 W. | 1900 | do | 1,011 | 1,011 | 582 | do | | | 6.131 | Do. |
| 171 | Bloomington Land Co | Sec. 22, T. 1 S., R. 5 W. | 1900 | 12-inch pipe | 1,100 | 858 | 454 | do | $1,200 | | | Not used. |
| 172 | D. Johnson | Sec. 8, T. 1 S., R. 4 W. | | 8-inch pipe | 1,095 | 1,081 | 283 | | 600 | | | Do. |
| 173 | Fox, Archibald & Lantz | do | | | 1,089 | | | Centrifugal; 10 gas | | | .414 | Irrigation. |
| 174 | Jas. Lamb | do | 1894 | 8-inch pipe | 1,097 | 1,083 | 102 | do | 200 | $1,800 | .400 | Do. |
| 175 | Jas. Barnhill | do | | do | 1,097 | | | Centrifugal; 15 electric | | | .800 | Do. |
| 176 | City of Colton | do | 1899 | 10-inch pipe | 1,087 | 1,070 | 490 | Centrifugal; electric | | | .834 | Irrigation; domestic. |
| 177 | do | do | 1899 | 8-inch pipe | 1,084 | 1,068 | 90 | do | | | .200 | Do. |
| 178 | G. W. Curtis | Sec. 24, T. 1 S., R. 4 W. | 1895 | 7-inch pipe | 1,088 | 1,063 | 85 | 8 wind | 130 | 70 | .002 | Do. |
| 179 | J. J. Curtis | do | 1892 | do | 1,088 | 1,063 | 90 | do | 150 | 120 | .008 | Do. |
| 180 | A. C. Harvey | do | 1898 | do | 1,088 | 1,088 | 600 | Centrifugal; 12 gas | 400 | 1,200 | 2.250 | Irrigation. |
| 181 | W. A. Thomas | do | | | 1,078 | 1,076 | | Artesian | | | | |
| 182 | L. S. Dart | Sec. 25, T. 1 S., R. 4 W. | 1890 | 7-inch pipe | 1,075 | 1,055 | 80 | 12 wind | 150 | | .002 | Domestic. |
| 183 | Anderson estate | do | | 8-inch pipe<br>4.5-inch pipe | 1,093 | | 450<br>150 | Centrifugal; 25 gas | | 2,275 | .250 | Irrigation. |
| 184 | A. Hunt | Sec. 27, T. 1 S., R. 4 W. | 1889 | 7-inch pipe | 1,005 | 1,005 | 127 | Artesian | 200 | | .100 | Irrigation; domestic. |
| 185 | do | do | 1889 | do | 1,001 | 1,001 | 57 | do | 90 | | .800 | Irrigation. |
| 186 | do | do | 1895 | 9¼-inch pipe | 1,004 | 1,004 | 280 | do | 1,100 | | .400 | Do. |
| 187 | do | do | 1894 | 7-inch pipe | 1,007 | 1,007 | 200 | do | 500 | | | Do. |
| 188 | No record. | | | | | | | | | | | |
| 189 | E. M. Cooley | do | 1889 | do | 1,019 | 959 | 86 | 12 wind | 150 | 100 | | Irrigation; domestic. |
| 190 | H. L. Drew | Sec. 21, T. 1 S., R. 4 W. | | 3-inch pipe | 980 | 980 | 200 | Artesian | | | .010 | Domestic. |
| 191 | C. C. Cooley | Sec. 27, T. 1 S., R. 4 W. | 1885 | 7-inch pipe | 993 | 928 | 85 | 12 wind | 150 | 100 | | Do. |
| 192 | P. Filance | do | 1887 | 10-inch pipe | 983 | 983 | 250 | Artesian | 1,000 | | 1.200 | Irrigation. |
| 193 | Filance estate | do | 1880 | 3-inch pipe (3) | 984 | 984 | 75<br>85<br>90 | do | | | .900 | Irrigation; domestic. |
| 194 | O. A. Byrne | Sec. 21, T. 1 S., R. 4 W. | | 2-inch pipe | 984 | 980 | | Hand | | 5 | | Domestic. |
| 195 | Harry Whaley | Sec. 34, T. 1 S., R. 4 W. | 1890 | 7-inch pipe | 1,150 | 1,115 | 100 | 8 wind | | | .001 | Do. |
| 196 | Thomas N. Hunt | do | 1890 | Dug, 3-foot diameter. | 1,117 | 1,000 | 123 | 16 wind | 750 | 100 | | Do. |
| 197 | Mr. Blair | do | 1899 | Dug, 5 by 5 foot | 1,115 | 1,109 | 16 | Never used | | | | |

*Wells in San Bernardino quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 198 | Ignacio Reyes | Sec. 34, T. 1 S., R. 4 W. | 1895 | Dug | 1,182 | 1,172 | 13 | | $15 | $3 | | Domestic. |
| 199 | Washington School | Sec. 27, T. 1 S., R. 4 W. | | 7-inch pipe | 1,043 | 966 | 129 | 8 wind | | 90 | | Do. |
| 200 | S. A. Pooles | Sec. 33, T. 1 S., R. 4 W. | 1890 | do | 1,015 | 955 | 75 | 12 wind | | 500 | .005 | |
| 201 | Fred Pooles | do | 1901 | 8¼-inch pipe | 955 | 907 | 98 | 8 wind | | | | Do. |
| 202 | Mrs. C. A. Peake | do | 1880 | 2-inch pipe | 950 | 936 | 18 | Hand | 10 | | | Do. |
| 203 | Chas. Green | do | | 3-inch pipe | 944 | | 3 | Wind | | | | Do. |
| 204 | J. D. Warner | Sec. 28, T. 1 S., R. 4 W. | 1884 | 1¼-inch pipe | 938 | 927 | 13 | Hand | 10 | | | Do. |
| 205 | do | do | 1898 | 1¼-inch pipe | 926 | 916 | 13 | do | 8 | | | Do. |
| 206 | do | do | 1894 | 10-inch pipe | 941 | 935 | 155 | | 2,455 | | | |
| 207 | Geo. Cooley, sr | Sec. 27, T. 1 S., R. 4 W. | 1894 | 7-inch pipe | 978 | 952 | 72 | 12 wind | | 125 | .005 | Irrigation; domestic. |
| 208 | C. A. Poole | do | 1900 | do | 1,002 | 984 | 50 | Hand | 110 | | | Domestic. |
| 209 | A. A. Warren | Sec. 33, T. 1 S., R. 4 W. | 1885 | 2-inch pipe | 936 | 929 | 25 | 12 wind | 15 | 150 | .002 | Irrigation; domestic. |
| 210 | West Riverside Water Co. | Sec. 32, T. 1 S., R. 4 W. | | | 950 | 944 | 112 | 30 compressor | | 1,275 | | Irrigation. |
| 211 | J. M. Snodgrass | Sec. 28, T. 1 S., R. 4 W. | 1898 | Dug, 10-foot diameter. | 931 | 927 | 13 | Bucket pump; engine | 50 | 600 | .500 | Do. |
| 212 | do | do | 1898 | Dug, 2-foot diameter. | 923 | 920 | 7.5 | 12 wind | 10 | 50 | .003 | Do. |
| 213 | A. A. Warren | Sec. 33, T. 1 S., R. 4 W. | 1897 | 2-inch pipe | 943 | 936 | 15 | Hand | 15 | 5 | | Domestic |
| 214 | Southern Pacific R. R. Co. | Sec. 21, T. 1 S., R. 4 W. | 1882 | 7-inch pipe | 958 | 915 | 45 | 12 wind | | | .005 | Do. |
| 215 | Frank Parody | Sec. 28, T. 1 S., R. 4 W. | 1900 | Dug | 955 | 934 | 33 | Hand | | 12 | | Do. |
| 216 | Martin Gahm | Sec. 21, T. 1 S., R. 4 W. | 1888 | Dug, 3 by 3 foot | 964 | 927 | 41 | 8 wind | 50 | 75 | .005 | Do. |
| 217 | W. H. Wells | do | 1893 | Dug, 2.5 by 2.5 foot. | 966 | 928 | 41 | Hand | 6 | | | Do. |
| 218 | C. G. Turner | do | 1895 | 7-inch pipe | 966 | | 70 | 12 wind | | | | |
| 219 | G. B. Kinyon | do | 1888 | Dug, 3 by 3 foot | 948 | 931 | 25 | Wind | 25 | 500 | | Irrigation; domestic. |
| 220 | J. F. Stuchberry | do | 1896 | Dug, 3.5 by 3.5 foot. | 959 | 933 | 29 | 8 wind | 10 | 90 | .007 | Do. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 221 | J. H. Vaughan | do | 1886 | Dug, 4-foot diameter. | 955 | 934 | 27 | 12 wind | 48 | 75 | .009 | Do. |
| 222 | Alfred Vaughan | do | 1900 | do | 959 | 928 | 34 | do | 62 | 155 | | Irrigation. |
| 223 | W. L. Vaughan | do | 1884 | do | 965 | | | do | | | .009 | Irrigation; domestic. |
| 224 | H. D. Young | do | 1890 | Dug, 2-foot diameter. | 963 | 931 | 40 | Hand | 40 | | | Domestic. |
| 225 | J. H. Dodson | do | 1885 | Dug, 4-foot diameter. | 969 | 926 | 50 | 8 wind | | 105 | .003 | Irrigation; domestic. |
| 226 | Henry Kaiser | do | 1892 | do | 964 | 922 | 43 | 12 wind | 84 | | .006 | Do. |
| 227 | H. C. Dodson | do | 1892 | Dug, 2-foot diameter. | 968 | 928 | 55 | 8 wind | | 212 | | Do. |
| 228 | John Benner | do | 1880 | Dug, 4-foot diameter. | 970 | 916 | 62 | 12 wind | | | .002 | Do. |
| 229 | Tom Moran | do | | do | 974 | 921 | 54 | Hand | | | Small. | Domestic. |
| 230 | T. Allen | do | 1880 | do | 978 | 924 | 68 | 14 wind | | 155 | .001 | Do. |
| 231 | S. A. Woodard | do | 1882 | Dug, 4.5-foot diameter. | 984 | 928 | 69 | 12 wind | | | .009 | Irrigation; domestic. |
| 232 | Los Angeles Building Co. | do | | Dug, 4 by 4 foot | 1,000 | Dry. | 70 | 10 wind | | | | |
| 233 | J. A. Coburn | Sec. 16, T. 1 S., R. 4 W. | 1890 | do | 1,000 | 934 | 80 | 12 wind | | | .005 | Do. |
| 234 | Miss B. Top | do | | | 1,038 | 1,038 | 3 | 8 wind | 5 | 65 | .002 | Do. |
| 235 | Byron Waters | do | 1893 | Dug, 9.5 by 9.5 foot and 5 by 5 foot. | 1,019 | 991 | 28 | Centrifugal; 3 electric | 300 | 376 | .6 | Do. |
| 235a | do | do | 1889 | 3-inch pipe | 1,019 | | 220 | Artesian | 700 | | .005 | Do. |
| 236 | Doctor Rowl | | | Pipe | | | | do | | | | |
| 237 | do | | | do | | | | do | | | | |
| 238 | Homer Jones | Sec. 16, T. 1 S., R. 4 W. | 1895 | 3-inch pipe | 1,023 | 1,010 | 300 | 8 wind | | | .002 | Do. |
| 239 | Mrs. M. G. Hammel | do | | | 1,008 | 1,000 | 83 | do | | 75 | .002 | Do. |
| 240 | Riverside Trust Co. | Sec. 23, T. 1 S., R. 4 W. | | 7-inch pipe | 1,000 | | | Hand | | | | Domestic. |
| 241 | F. S. West | do | 1897 | 2-inch pipe | 998 | | | | | | | Irrigation; domestic. |
| 242 | Mrs. E. A. Paine | Sec. 22, T. 1 S., R. 4 W. | 1896 | 3-inch pipe | 1,000 | 1,000 | 109 | Artesian | | 75 | .04 | Do. |
| 243 | M. B. Warren | do | 1885 | 4-inch pipe | 996 | 996 | 125 | do | | | .01 | Do. |
| 243a | do | 50 feet southeast from 243. | 1899 | 3-inch pipe | 997 | 997 | 130 | do | | | .25 | Irrigation. |
| 244 | do | Sec. 22, T. 1 S., R. 4 W. | 1880 | 2-inch pipe | 998 | 998 | 125 | do | | | .041 | Irrigation; domestic. |

*Wells in San Bernardino quadrangle*—Continued.

| No. of well | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 244a | M. B. Warren | 20 feet southwest from 244. | 1899 | 3-inch pipe | 997 | 997 | | Artesian | | | .178 | Irrigation; domestic. |
| 245 | C. E. Bishop | Sec. 23, T. 1 S., R. 4 W. | 1882 | do | 1,001 | 1,001 | 94 | do | $125 | | .02 | Do. |
| 245a | do | do | 1888 | 7-inch pipe | 1,004 | 1,004 | 94 | do | | | .02 | Do. |
| 246 | Wm. E. Everett | Sec. 22, T. 1 S., R. 4 W. | 1898 | 3-inch pipe | 1,001 | 1,001 | 96 | do | 100 | | .25 | Do. |
| 247 | Bob Gomer | Sec. 15, T. 1 S., R. 4 W. | 1890 | do | 984 | | | | | | | |
| 248 | John Welsh | Sec. 23, T. 1 S., R. 4 W. | | do | 1,007 | 1,007 | 100 | Artesian | | | .083 | Do. |
| 249 | S. B. Parish | Sec. 14, T. 1 S., R. 4 W. | 1892 | 10-inch pipe | 1,019 | 1,019 | 540 | do | 2,500 | | .40 | Irrigation. |
| 250 | do | do | 1885 | 6-inch pipe | 1,017 | 1,015 | 104 | | 300 | | | |
| 251 | do | do | 1889 | 2-inch pipe | 1,016 | | 100 | | 150 | | | |
| 252 | do | do | 1870 | 1¼-inch pipe | 1,014 | 1,014 | 83 | Artesian | | | .004 | |
| 253 | Mrs. Elizabeth Case | do | 1898 | 3-inch pipe | 1,007 | 1,007 | 91 | do | 85 | | .115 | Irrigation; domestic. |
| 254 | do | do | 1892 | 7-inch pipe | 1,009 | 1,009 | 260 | do | 500 | | .2 | Irrigation. |
| 254a | W. G. Merrilees | do | 1893 | do | 1,009 | 1,009 | 211 | do | | | .14 | Do. |
| 254b | do | do | 1897 | 3-inch pipe | 1,009 | 1,009 | 86 | do | | | Small. | Do. |
| 255 | Wm. Stewart | Sec. 15, T. 1 S., R. 4 W. | 1898 | 8-inch pipe | 1,004 | 1,004 | 315 | do | | | [a] 1.14 | Do. |
| 256 | do | do | 1898 | 9-inch pipe | 1,005 | 1,005 | 85 | do | | | [b] .2 | Do. |
| 257 | do | do | | 1¼-inch pipe | 1,004 | 1,004 | | do | | | Small. | Domestic. |
| 259 | do | do | | 7-inch pipe | 1,002 | | | | | | | Irrigation. |
| 260 | John Sullivan | Sec. 14, T. 1 S., R. 4 W. | 1874 | 2-inch pipe | 1,021 | | | | 100 | | ([c]) | Irrigation; domestic. |
| 261 | do | do | 1893 | 3-inch pipe | 1,024 | 1,024 | 210 | Artesian | 325 | | .062 | |
| 263 | do | do | 1884 | 7-inch pipe | 1,025 | 1,023 | 84 | | 80 | | ([d]) | |
| 264 | do | do | 1871 | 2-inch pipe | 1,037 | | 90 | | | | ([d]) | |
| 265 | | do | 1892 | do | 1,022 | | 92 | Artesian | | | .002 | Domestic. |
| 266 | Wm. Baker | do | 1870 | 1.5-inch pipe | 1,022 | 1,022 | 96 | do | 100 | | Small | Do. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 267 | .....do | .....do | 1899 | 3-inch pipe | 1,024 | 1,024 | 271 | .....do | 435 | | .178 | Domestic; irrigation. |
| 268 | P. J. Clevenger | .....do | | 2-inch pipe | 1,030 | | | 10 electric; centrifugal | | | (c) | |
| 269 | .....do | .....do | 1897 | 10-inch pipe | 1,043 | | 150 | | | | .5 | Irrigation. |
| 270 | Henry Warren | .....do | 1883 | 2-inch pipe | 1,033 | 1,023 | 106 | | 150 | | (d) | |
| 271 | .....do | .....do | 1890 | 3-inch pipe | 1,033 | 1,023 | 100 | 12 wind | 100 | $160 | (d) | Domestic; irrigation. |
| 272 | John Sullivan | .....do | 1898 | .....do | 1,024 | 1,024 | 214 | Artesian | 300 | | .178 | Irrigation. |
| 273 | Henry Warren | .....do | 1880 | 7-inch pipe | 1,036 | 1,026 | 106 | | 200 | | (e) | Not used. |
| 274 | .....do | .....do | 1880 | .....do | 1,038 | 1,028 | 220 | | 500 | | (f) | Do. |
| 275 | .....do | .....do | 1893 | 10-inch pipe | 1,039 | 1,039 | 640 | Artesian | 3,000 | | .386 | Irrigation. |
| 276 | Frank Feri | .....do | | 2-inch pipe | 1,034 | | | Hand | | | (g) | Domestic. |
| 277 | G. Renwick | Sec. 8, T. 1 S., R. 4 W | | 6-inch pipe | 1,090 | 1,055 | 186 | 8 wind | | | Small. | Do. |
| 278 | Orange Land and Water Co. | .....do | | 7-inch pipe | 1,089 | 1,069 | 225 | Centrifugal; 20 compressor; 3 wells in group together. | | | 1.64 | Domestic; irrigation. |
| 279 | Callahan estate | Sec. 20, T. 1 S., R. 4 W | 1886 | Dug, 4 by 4 foot | 1,009 | 933 | 84 | 12 wind | | | | |
| 280 | E. Memory | .....do | 1886 | .....do | 982 | 927 | 60 | .....do | | | Small. | Domestic. |
| 281 | F. A. Cleveland | Sec. 8, T. 1 S., R. 4 W | 1898 | 2-inch pipe | 1,072 | | 90 | 8 wind | 47 | 40 | Small. | Do. |
| 282 | C. H. Westmyer | .....do | 1897 | 3-inch pipe | 1,069 | 1,062 | 94 | .....do | 74 | 100 | Small. | Domestic; irrigation. |
| 283 | W. W. Brison | Sec. 9, T. 1 S., R. 4 W | 1899 | 2-inch pipe | 1,062 | 1,052 | 99 | 10 wind | 100 | 200 | Small. | Domestic. |
| 284 | G. F. Woods | .....do | 1900 | 8-inch pipe | 1,059 | 1,049 | 140 | .....do | 300 | 350 | .008 | Domestic; irrigation. |
| 285 | .....do | .....do | 1887 | 7-inch pipe | 1,060 | 1,060 | 300 | | | | None. | |
| 286 | City of Colton | Sec. 8, T. 1 S., R. 4 W | | 10-inch pipe (2)<br>7-inch pipe (2) | 1,065 | | 200<br>640 | Centrifugal; 20 electric | | 2,000 | 2.500 | Do. |
| 287 | Isaac Jameson | .....do | 1898 | 8-inch pipe | 1,070 | 1,050 | 90 | 12 wind | 126 | 275 | .015 | Do. |
| 288 | J. Collins | .....do | 1887 | 3-inch pipe | 1,054 | | 75 | 10 wind | | | Small. | Irrigation; domestic. |
| 289 | J. C. Ralphs | Sec. 9, T. 1 S., R. 4 W | 1899 | 10-inch pipe | 1,047 | 1,016 | 202 | 12 wind | 500 | 200 | Small. | Do. |
| 290 | Los Angeles Building Co. | .....do | 1893 | .....do | 1,052 | | 160 | 8 gas; centrifugal | | | .8 | Irrigation. |
| 291 | V. Herkelrath | Sec. 15, T. 1 S., R. 4 W | 1882 | 2-inch pipe | 979 | 979 | | Artesian | 70 | | .072 | Domestic. |
| 292 | .....do | .....do | 1880 | .....do | 980 | 980 | | .....do | 175 | | .119 | Irrigation. |
| 293 | Mrs. Nowland | .....do | 1875 | .....do | 980 | 980 | 160 | .....do | 275 | | | Do. |

a 1899. b 1898. c Stopped flowing in 1895. d Stopped flowing in 1898. e Stopped flowing in 1889. f 1890. g May, 1900.

*Wells in San Bernardino quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 294 | M. H. Hurd | Sec. 15, T. 1 S., R. 4 W. | 1887 | 2-inch pipe | 983 | | | Artesian | | | | Domestic. |
| 295 | Mrs. N. H. Ball | do | 1894 | 7-inch pipe | 996 | 996 | 253 | do | $500 | | .262 | Irrigation. |
| 296 | Los Angeles Building Co. | Sec. 9, T. 1 S., R. 4 W. | | 10-inch pipe | 1,051 | 1,049 | 446 | do | | | .4 | Do. |
| 297 | do | do | | do | 1,050 | 1,048 | 451 | do | | | .4 | Do. |
| 298 | Mrs. N. H. Ball | Sec. 15, T. 1 S., R. 4 W. | 1886 | 3-inch pipe | 992 | 992 | 107 | do | 250 | | | Domestic. |
| 299 | W. Beck | do | 1892 | do | 998 | 988 | 204 | do | | | | Irrigation. |
| 300 | H. Kleuter | Sec. 10, T. 1 S., R. 4 W. | 1885 | do | 1,006 | 1,006 | 200 | do | 300 | | .074 | Domestic; irrigation. |
| 301 | do | do | 1887 | do | 1,005 | 1,005 | 206 | do | 328 | | | Irrigation. |
| 302 | do | do | 1887 | do | 1,005 | 1,005 | 132 | do | 159 | | .518 | Do. |
| 303 | do | do | 1897 | do | 1,003 | 1,003 | 135 | do | 125 | | .006 | Do. |
| 304 | Stephen Wood | Sec. 11, T. 1 S., R. 4 W. | 1894 | do | 1,010 | 1,010 | 160 | do | | | Small. | Domestic. |
| 305 | W. B. Barton | Sec. 14, T. 1 S., R. 4 W. | 1883 | 2-inch pipe | 1,041 | | 100 | 12 wind | | $216 | Small. | Do. |
| 306 | Stephen Wood | Sec. 11, T. 1 S., R. 4 W. | 1880 | 3-inch pipe | 1,022 | | 164 | 8 wind | | | Small. | Stock. |
| 307 | F. M. Kellar | do | 1882 | do | 1,024 | 1,024 | 267 | Artesian | 500 | | .02 | Domestic. |
| 308 | W. B. Barton | Sec. 13, T. 1 S., R. 4 W. | 1892 | 10-inch pipe | 1,045 | 1,033 | 115 | 9 gas; centrifugal | | | .209 | Irrigation. |
| 309 | A. J. Downer | do | | 3-inch pipe | 1,045 | | 190 | 12 wind | 125 | 50 | Small. | Domestic. |
| 310 | Edwin Martin | do | | do | 1,045 | 1,033 | 215 | Hand | | | Small. | Do. |
| 311 | Lucas Hoagland | do | 1897 | 2-inch pipe | 1,049 | 1,039 | 80 | do | 75 | | Small. | Do. |
| 312 | do | do | 1884 | 3-inch pipe | 1,050 | 1,040 | 250 | 8 wind | 250 | 75 | Small. | Stock. |
| 313 | do | Sec. 12, T. 1 S., R. 4 W. | 1881 | 2-inch pipe | 1,047 | | 100 | | 100 | | | Not used. |
| 314 | R. F. Garner | Sec. 10, T. 1 S., R. 4 W. | 1888 | | 1,019 | | 200 | Artesian | | | Small. | Domestic. |
| 315 | | Sec. 12, T. 1 S., R. 4 W. | | 10-inch pipe | 1,059 | 1,059 | 682+ | do | | | .123 | Stock. |
| 316 | Geo. M. Cooley | Sec. 36, T. 1 N., R. 4 W. | 1892 | 7-inch pipe | 1,150 | 1,108 | 66 | 12 wind | | 500 | | Irrigation; domestic. |
| 317 | do | do | 1895 | 11-inch pipe | 1,150 | 1,108 | 80 | 9 gas | | 1,500 | .6 | Irrigation. |
| 317a | do | do | 1895 | 10-inch pipe | 1,150 | 1,108 | 80 | 9¼ cylinder pumps | | | | Do. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 318 | E. J. Stiles | Sec. 35, T. 1 N., R. 4 W. | 1898 | 7-inch pipe | 1,196 | 1,157 | 48 | 10 wind | 40 | 160 | Small. | Domestic; stock. |
| 319 | Jas. Dickson | do | 1888 | 10-inch pipe | 1,179 | 1,145 | 44 | 12 wind | | 135 | Small. | Domestic. |
| 320 | J. G. Wood | do | 1884 | 7-inch pipe | 1,124 | 1,090 | 44 | do | | 200 | Small. | Do. |
| 321 | do | Sec. 36, T. 1 N., R. 4 W. | 1885 | 11-inch pipe | 1,140 | 1,092 | 64 | Cylinder pump; 5 gas | 240 | 600 | .125 | Irrigation. |
| 322 | M. E. Myers | Sec. 35, T. 1 N., R. 4 W. | 1890 | 2-inch pipe | 1,111 | 1,089 | 310 | 12 wind | | | | Domestic; irrigation. |
| 323 | J. S. Bean | Sec. 3, T. 1 S., R. 4 W. | 1889 | 3-inch pipe | 1,108 | 1,108 | 210 | Artesian | 200 | | .1 | Irrigation. |
| 324 | do | do | 1898 | 10-inch pipe | 1,108 | 1,108 | 524 | do | 1,100 | | .9 | Do. |
| 325 | J. F. Johnson | Sec. 34, T. 1 N., R. 4 W. | 1890 | 7-inch pipe | 1,098 | 1,076 | 39 | Hand | | | | Not used. |
| 326 | Oscar Perris | Sec. 26, T. 1 N., R. 4 W. | | | 1,177 | | 96 | Steam; power | | | | Irrigation. |
| 327 | S. G. Ramsey | Sec. 25, T. 1 N., R. 4 W. | 1896 | 10-inch pipe | 1,190 | 1,125 | 90 | Power; 10 gas | 160 | 1,200 | .3 | Do. |
| 328 | Saml. S. Ford | Sec. 26, T. 1 N., R. 4 W. | 1898 | Dug, 3-foot diameter. | 1,185 | (a) | 58 | Wind | | 225 | None. | |
| 329 | Muscupiabe Land and Water Co. | Sec. 23, T. 1 N., R. 4 W. | 1899 | 10-inch pipe | 1,288 | 1,143 | 402 | Power; 15 steam | 1,200 | 2,000 | .5 | Domestic; irrigation; stock. |
| 330 | do | Sec. 26, T. 1 N., R. 4 W. | 1892 | do | 1,222 | (a) | 102 | Wind | 300 | 250 | None. | |
| 331 | Mrs. Anne C. Severance | do | 1895 | do | 1,227 | (a) | 106 | 12 wind | 300 | 900 | None. | |
| 332 | Mrs. S. A. Smith | Sec. 27, T. 1 N., R. 4 W. | 1894 | do | 1,224 | 1,224 | 140 | 16 wind | | 800 | .010 | Irrigation; domestic. |
| 333 | F. M. Johnson | Sec. 34, T. 1 N., R. 4 W. | 1899 | 10-inch pipe | 1,117 | 1,095 | 600 | 10 gas; cylinder pump | 1,160 | 800 | .230 | Irrigation. |
| 334 | do | do | 1880 | 12-inch pipe | 1,112 | 1,084 | 40 | Wind | | | Small. | Stock; domestic. |
| 335 | H. H. Fitting | Sec. 35, T. 1 N., R. 4 W. | 1885 | 7-inch pipe | 1,124 | | 44 | do | | | Small. | Do. |
| 336 | do | do | 1888 | Dug, 6 by 6 foot | 1,135 | (a) | 47 | 4½ gas; cylinder pump | 100 | | | |
| 337 | do | do | 1886 | 3-inch pipe | 1,131 | | 325 | | 1,000 | | Dry. | |
| 338 | C. Hansen | do | 1895 | 7-inch pipe | 1,127 | 1,090 | 39 | 8 wind | | 200 | Small. | Do. |
| 339 | N. Holen | do | 1895 | do | 1,127 | 1,090 | 47 | | | | Small. | Do. |
| 340 | John Anderson | Sec. 34, T. 1 N., R. 4 W. | 1885 | do | 1,130 | | 90 | 8 wind | 114 | 100 | Small. | Do. |
| 341 | H. N. Stones | do | 1884 | do | 1,141 | 1,087 | 85 | do | | 125 | Small. | Do. |
| 342 | M. F. Swing | do | 1891 | do | 1,151 | | 93 | 12 wind | | 220 | | Domestic; stock. |
| 343 | do | do | 1894 | do | 1,152 | | 87 | do | | | | Irrigation. |
| 344 | A. R. Togg | do | 1891 | do | 1,160 | | 100 | do | | | Small. | Irrigation; domestic. |
| 345 | F. L. Smith | do | 1897 | do | 1,163 | | 106 | 10 wind | 105 | 135 | .002 | Do. |
| 346 | John W. Anderson | do | 1880 | do | 1,165 | 1,103 | 70 | do | 75 | 175 | .002 | Irrigation. |

a No water.

*Wells in San Bernardino quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 347 | John W. Anderson | Sec. 34, T. 1 N., R. 4 W. | 1900 | 7-inch pipe | 1,166 | 1,103 | 113 | 16 wind | $125 | $225 | 0.004 | Irrigation. |
| 348 | S. E. Pearson | Sec. 27, T. 1 N., R. 4 W. | 1899 | do | 1,182 | 1,107 | 104 | 12 wind | 135 | 60 | Small. | Irrigation; domestic. |
| 349 | R. Meacham | do | 1900 | do | 1,183 | | 110 | do | | | Small. | Irrigation; stock. |
| 350 | do | do | 1890 | do | 1,172 | (a) | 64 | do | | | None. | |
| 351 | J. H. Taylor | do | 1896 | do | 1,188 | (a) | 62 | 8 wind | 50 | 100 | None. | |
| 352 | W. G. Warner | do | 1899 | do | 1,189 | 1,119 | 80 | 10 steam | | | | Not used. |
| 353 | F. D. Olmstead | do | 1895 | do | 1,190 | | 101 | 12 wind | | 100 | Small. | Irrigation; domestic. |
| 354 | S. F. Kelley | Sec. 28, T. 1 N., R. 4 W. | 1897 | do | 1,170 | 1,121 | 115 | 8 wind | | | Small. | Do. |
| 355 | S. F. Kelley et al | do | 1900 | 12-inch pipe | 1,185 | 1,127 | 208 | Electric; centrifugal | 1,700 | 1,171 | .9 | Irrigation. |
| 355a | do | do | 1899 | 10-inch pipe | 1,185 | 1,127 | 460 | | | | | |
| 356 | H. C. Ward | do | | 7-inch pipe | 1,177 | 1,118 | 120 | 12 wind | | | Small. | Do. |
| 357 | S. H. Johnson | do | 1885 | do | 1,182 | 1,122 | 84 | 10 wind | | 250 | Small. | Domestic. |
| 358 | H. Giddings | do | 1898 | do | 1,205 | 1,148 | 73 | 15 wind | | 125 | | Do. |
| 359 | W. G. Rowland | do | 1893 | do | 1,224 | 1,156 | 112 | Geared pump; 3 gas | 125 | 625 | .1 | Irrigation. |
| 360 | Fred Heilemann | Sec. 32, T. 1 N., R. 4 W. | 1889 | do | 1,227 | 1,147 | 146 | 16 wind | 200 | 750 | .008 | Irrigation; domestic. |
| 361 | do | do | 1894 | do | 1,228 | 1,148 | 129 | 18 wind | | | .012 | Do. |
| 362 | do | Sec. 29, T. 1 N., R. 4 W. | 1890 | 10-inch, 8-inch, and 6½-inch pipes. | 1,245 | 1,155 | 1,025 | | 7,000 | | (b) | |
| 363 | B. E. Wheeler | do | 1898 | 10-inch pipe | 1,258 | 1,152 | 125 | Plunger pump; 5 gas | 300 | 800 | | Do. |
| 364 | F. Alvarado | Sec. 32, T. 1 N., R. 4 W. | 1900 | 7-inch pipe | 1,188 | 1,135 | 93 | | | | | Not used. |
| 365 | A. B. Hancock | Sec. 5, T. 1 S., R. 4 W. | 1896 | do | 1,170 | | 56 | 12 wind | 125 | 100 | Small. | Domestic; irrigation; stock. |
| 366 | do | do | 1882 | do | 1,169 | | 56 | do | | | | Do. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 367 | D. W. White | Sec. 4, T. 1 S., R. 4 W. | 1871 | do | 1,109 | 1,089 | 195 | Gas; centrifugal; 8 wind. | 1,200 | 200 | .400 | Irrigation; domestic. |
| 368 | W. F. Holcomb | Sec. 33, T. 1 N., R. 4 W. | | do | 1,115 | 1,089 | 37 | | | | Small. | Domestic. |
| 369 | Alex. Wixom | Sec. 4, T. 1 S., R. 4 W. | 1899 | 8-inch pipe | 1,117 | | 45 | 12 wind | 50 | 148 | Small. | Do. |
| 370 | F. L. Holcomb | Sec. 33, T. 1 N., R. 4 W. | 1885 | 7-inch pipe | 1,128 | 1,100 | 47 | do | 100 | 150 | Small. | Do. |
| 371 | do | do | 1885 | do | 1,133 | 1,103 | 47 | do | 100 | 150 | Small. | Stock. |
| 372 | J. J. Whitney | Sec. 4, T. 1 S., R. 4 W. | 1884 | Pipe | 1,129 | 1,101 | 112 | Wind | | 400 | Small. | Domestic; stock. |
| 373 | P. B. Hockaday | do | 1887 | 7-inch pipe | 1,133 | | 110 | 12 wind | | 500 | Small. | Domestic; irrigation. |
| 374 | J. J. Morris, sr. | Sec. 5, T. 1 S., R. 4 W. | 1890 | 8-inch pipe | 1,137 | 1,109 | 53 | 10 wind | | 75 | Small. | Do. |
| 375 | Dexter Field | do | 1870 | 6-inch pipe | 1,147 | 1,112 | 45 | do | | | Small. | Domestic. |
| 376 | C. A. Muscott | Sec 32, T. 1 N., R. 4 W. | 1886 | 8-inch pipe | 1,158 | 1,115 | 78 | 12 wind | 100 | 250 | | Domestic; irrigation. |
| 377 | J. W. Roberts | Sec. 27, T. 1 N., R. 4 W. | 1899 | 10-inch pipe | 1,210 | 1,155 | 160 | Plunger pump; 5 electric. | 400 | 900 | .24 | Do. |
| 378 | T. C. Parker | Sec. 32, T. 1 N., R. 4 W. | 1886 | 7-inch pipe | 1,205 | 1,110 | 98 | 12 wind; 3 gas | | 550 | | Do. |
| 379 | P. Oldecker | Sec. 33, T. 1 N., R. 4 W. | 1893 | 7-inch pipe | 1,195 | | 133 | Geared pump; 2 gas | | 400 | .10 | Do. |
| 380 | A. Petersen | do | 1890 | do | 1,192 | 1,134 | 76 | 12 wind | 50 | 100 | Small. | Do. |
| 381 | C. A. Bruckman | Sec. 32, T. 1 N., R. 4 W. | 1894 | 10-inch pipe | 1,221 | 1,151 | 146 | Geared pump; 16 gas | 325 | 775 | .36 | Irrigation. |
| 382 | do | do | 1892 | 7-inch pipe | 1,215 | 1,145 | 84 | 12 wind | 115 | 300 | | Do. |
| 383 | do | do | 1892 | do | 1,214 | 1,144 | 85 | Geared pump; 5 gas | 115 | 625 | .042 | Do. |
| 384 | do | do | 1890 | do | 1,192 | 1,134 | 85 | 12 wind | 115 | 250 | Small. | Domestic. |
| 385 | Wilson & Wheat | do | 1890 | do | 1,188 | 1,128 | 82 | 16 wind | | | | Domestic; irrigation. |
| 386 | E. D. Palmer | Sec. 33, T. 1 N., R. 4 W. | 1894 | do | 1,184 | | 80 | 14 wind | | | Small. | Do. |
| 387 | C. G. Leonhardt | Sec. 32, T. 1 N., R. 4 W. | 1890 | do | 1,182 | | 85 | 12 wind | 115 | 192 | Small. | Do. |
| 388 | do | do | 1899 | 8-inch pipe | 1,197 | 1,133 | 90 | do | 125 | 297 | .006 | Irrigation. |
| 389 | S. E. A. Palmer | Sec. 33, T. 1 N., R. 4 W. | 1887 | 7-inch pipe | 1,176 | 1,124 | 92 | 14 wind | 150 | 350 | .003 | Domestic; irrigation. |
| 390 | Fred F. Palmer | do | 1899 | Dug, 4 by 6 foot; 7-inch pipe. | 1,189 | 1,134 | 85 | Duplex; steam | 300 | 500 | .036 | Irrigation. |
| 391 | W. D. Wilson | Sec. 32, T. 1 N., R. 4 W. | 1893 | 8-inch pipe | 1,203 | 1,138 | 94 | 12 wind | | | | Do. |
| 392 | S. H. Harmon | do | 1893 | 10-inch pipe | 1,191 | 1,132 | 133 | Geared pump; 5 gas | 1,200 | (c) | .020 | Do. |
| 393 | S. W. Harmon | do | 1882 | 7-inch pipe | 1,181 | 1,128 | 83 | 12 wind | 50 | 220 | | Domestic; irrigation. |
| 394 | J. O. Slatter | Sec. 23, T. 1 N., R. 4 W. | 1890 | do | 1,155 | | 100 | do | | 150 | Small. | Domestic. |
| 395 | C. N. Damron | do | | do | 1,120 | 1,093 | 47 | 8 wind | | | Small. | Do. |

a No water. b Tools left in well. c Two wells.

*Wells in San Bernardino quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 396 | Mrs. Amy McCrary | Sec. 33, T. 1 N., R. 4 W. | 1899 | | 1,138 | 1,112 | 91 | Hand | | | Small. | Domestic. |
| 397 | Thos. Webster | do | 1898 | 7-inch pipe | 1,134 | | | 12 wind | | | | Do. |
| 398 | N. M. Swarthout | do | 1885 | do | 1,142 | 1,115 | 75 | 8 wind | $150 | $100 | Small. | Do. |
| 399 | do | do | 1895 | 10-inch pipe | 1,169 | | 80 | Horse | 100 | 35 | Small. | Irrigation. |
| 400 | J. H. Lytle | do | 1885 | 7-inch pipe | 1,166 | 1,135 | 79 | 12 wind | 75 | 50 | Small. | Domestic; irrigation. |
| 401 | H. S. Davidson | do | 1880 | do | 1,158 | | 56 | do | | 500 | | Do. |
| 402 | N. Swarthout | do | 1885 | do | 1,142 | 1,108 | 55 | 8 wind | | | Small. | Domestic. |
| 403 | G. W. Evans | do | 1887 | 6-inch pipe | 1,128 | 1,096 | 75 | do | | | Small. | Do. |
| 404 | R. M. Bradley | do | 1884 | 7-inch pipe | 1,101 | 1,082 | 90 | 12 wind | | | Small. | Do. |
| 405 | Mrs. Sarah Abel | do | 1880 | Dug, 3 foot diameter. | 1,109 | 1,088 | 22 | Bucket | | | Small. | Do. |
| 406 | R. Poppett | Sec. 34, T. 1 N., R. 4 W. | 1885 | 7-inch pipe | 1,109 | 1,085 | 45 | 12 wind | 50 | 140 | Small. | Domestic; irrigation. |
| 407 | G. Johnson | do | 1890 | do | 1,114 | 1,087 | 47 | 8 wind | 60 | 60 | Small. | Do. |
| 408 | E. G. Fish | do | 1889 | 2-inch pipe | 1,133 | | 425 | do | 1,000 | | Small. | Do. |
| 409 | C. Cohn | do | | 7-inch pipe | 1,118 | 1,089 | | 10 wind | | | Small. | Domestic. |
| 410 | O. B. Peck | do | 1888 | do | 1,147 | | 115 | 14 wind | | | Small. | Domestic; irrigation. |
| 411 | K. P. Stephens | do | 1883 | do | 1,164 | 1,114 | 65 | do | | | .008 | Do. |
| 412 | Jno. Y. Anderson | do | 1900 | 8-inch pipe<br>12-inch pipe | 1,165 | 1,109 | 150<br>400 | | 2,000 | | | Not used. |
| 413 | Jno. Lawrence | do | 1897 | 7-inch pipe | 1,091 | 1,076 | 42 | 8 wind | | 160 | Small. | Domestic. |
| 414 | J. C. Wees | do | 1898 | do | 1,097 | 1,073 | 46 | do | | | | Do. |
| 415 | Thos. J. Rennous | do | 1900 | do | 1,133 | 1,101 | 72 | 10 wind | 72 | 150 | Small. | Domestic; irrigation. |
| 416 | H. H. Ham | do | 1898 | do | 1,121 | 1,090 | 52 | 8 wind | 75 | 100 | Small | Do. |
| 417 | W. M. Jenkins | do | 1884 | do | 1,118 | 1,088 | 52 | 12 wind | | | Small | Do. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 418 | Oscar Wees | do | 1885 | do | 1,108 | | 48 | 8 wind | | | Small. | Domestic. |
| 419 | M. W. Davis | do | 1898 | do | 1,100 | | 42 | do | 40 | 90 | | Do. |
| 420 | P. W. Heap, jr | do | 1894 | do | 1,128 | 1,088 | 58 | 12 wind | 60 | 125 | .002 | Domestic; irrigation. |
| 421 | B. M. Wall | do | 1897 | 3-inch pipe | 1,100 | | 137 | 8 wind | | | Small. | Do. |
| 422 | E. Case | Sec. 3, T. 1 S., R. 4 W | 1899 | 8-inch pipe | 1,086 | 1,073 | 50 | Hand | | | Small. | Domestic. |
| 423 | Jno. E. Garner | Sec. 2, T. 1 S., R. 4 W | 1900 | do | 1,087 | 1,073 | 334 | Centrifugal; 8 gas | 750 | 750 | .800 | Irrigation, etc. |
| 424 | do | Sec. 35, T. 1 N., R. 4 W | 1888 | 10-inch pipe; 7-inch pipe. | 1,164 | 1,108 | 420 | Centrifugal; 20 electric | 1,500 | 3,000 | 1.200 | Irrigation. |
| 425 | Colton City Water Co | Sec. 31, T. 1 N., R. 4 W | 1900 | 10-inch pipe | 1,202 | | 208 | Centrifugal; 25 gas | | | 1.480 | Irrigation; domestic. |
| 426 | San Bernardino city waterworks. | Sec. 36, T. 1 N., R. 5 W | 1895<br>1900 | Two 11-inch pipes.<br>12-inch pipe | <br>1,239 | <br>1,207 | 320<br>550<br>800 | Centrifugal; 25 gas | | | 1.400 | City supply. |
| 427 | Riverside Highlands Water Co. | Sec. 31, T. 1 N., R. 4 W | 1900 | 10-inch pipe | 1,218 | 1,204 | 320 | | | | | Not used. |
| 428 | do | Sec. 36, T. 1 N., R. 5 W | 1892 | do | 1,246 | 1,211 | 650 | Centrifugal; 22 gas | 5,000 | 1,100 | 1.600 | Irrigation; domestic. |
| 429 | do | Sec. 31, T. 1 N., R. 4 W | 1893 | Two 10-inch pipes. | 1,250 | 1,201 | 350<br>300 | Centrifugal; 30 electric | 3,000 | 2,500 | 2.000 | Do. |
| 430 | do | do | | do | 1,258 | 1,203 | 500–600 | do | 3,000 | 2,500 | 2.800 | Do. |
| 431 | Rialto irrigation district Citizens' Water Co. | Sec. 36, T. 1 N., R. 5 W | 1891 | do | 1,255 | 1,204 | 450 | Centrifugal; turbine | 1,500 | | 1.300 | Do. |
| 432 | do | do | 1894 | 10-inch pipe | 1,260 | 1,207 | 460 | Centrifugal; 20 gas | 1,800 | 6,000 | .720 | Do. |
| 433 | F. E. Watkins | do | 1888 | do | 1,266 | 1,210 | 621 | Two 25 compressors | | | 890 | Irrigation. |
| 434 | Lytle Creek Water and Improvement Co. | do | 1900 | Three 12-inch pipes. | 1,290 | 1,215 | 226 | Duplex steam | 3,661 | 3,500 | 2.200 | Do. |
| 435 | Rialto irrigation district | Sec. 25, T. 1 N., R. 5 W | 1897 | 10-inch pipe | 1,333 | 1,303 | 520 | Centrifugal; 30 electric | 1,500 | 2,000 | 1.800 | Irrigation; domestic. |
| 436 | do | do | 1894 | do | 1,342 | 1,306 | 432 | do | 1,500 | 2,000 | 1.500 | Do. |
| 437 | Anglo-American Canaigre Co. | do | 1899 | Dug, 7 by 9 foot (2). | 1,337 | 1,307 | 45 | | | | | Not used. |
| 438 | F. E. Watkins | do | 1898 | 10-inch pipe | 1,390 | 1,251 | 381 | | 2,000 | | | Do. |
| 439 | Riverside Highlands Water Co. | Sec. 31, T. 1 N., R. 4 W | | 20 wells | 1,200–1,225 | | | | | | (a) | Irrigation. |
| 440 | | Sec. 4, T. 1 S., R. 4 W | | Dug, 4 by 4 foot | 1,089 | 1,083 | 7 | Hand | | | | Stock. |

a These 20 wells have nearly all ceased flowing.

*Wells in San Bernardino quadrangle*—Continued.

| No. of well. | Owner. | Location. | Year completed. | Class of well. | Elevation of surface. | Elevation of water, 1900. | Depth of well. | Method of lift. | Cost of well. | Cost of machinery. | Quantity of water. | Use of water. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Feet.* | *Feet.* | *Feet.* | | | | *Sec.-ft.* | |
| 441 | M. E. Brooks | Sec. 5, T. 1 S., R. 4 W. | 1886 | 3-inch pipe | 1,102 | | 132 | 8 wind | | | | Domestic; stock; irrigation. |
| 442 | do | do | | do | 1,105 | | 140 | 12 wind | | | Small. | Irrigation. |
| 443 | Mrs. Mary Bemis | do | 1888 | Pipe | 1,113 | | 132 | Hand | | | Small. | Domestic. |
| 444 | A. W. Bemis | do | 1890 | 8-inch pipe | 1,118 | 1,101 | 48 | 12 wind | | | Small. | Do. |
| 445 | do | do | 1894 | 10-inch pipe | 1,114 | 1,104 | 50 | Centrifugal; 3 gas | | $250 | 0.014 | Irrigation. |
| 446 | D. F. Probst | Sec. 4, T. 1 S., R. 4 W. | 1886 | 7-inch pipe | 1,085 | 1,070 | 36 | 10 wind | | | Small. | Domestic. |
| 447 | Mrs. A. Tompkins | Sec. 5, T. 1 S., R. 4 W. | 1882 | do | 1,115 | | 212 | Wind | $1,000 | 175 | Small. | Domestic; irrigation. |
| 448 | J. Hancock | do | 1875 | do | 1,138 | 1,092 | 128 | do | | | Small. | Do. |
| 449 | M. D. Reynolds | do | 1900 | 10-inch pipe | 1,136 | 1,106 | 146 | Centrifugal; 25 gas | 300 | 1,400 | .027 | Irrigation. |
| 450 | do | do | 1898 | 7-inch pipe | 1,116 | 1,094 | 40 | 8 wind | 60 | 150 | Small. | Domestic. |
| 451 | Mrs. M. Lord | Sec. 4, T. 1 S., R. 4 W. | 1888 | 3-inch pipe | 1,125 | | 150 | 10 wind | | | Small. | Do. |
| 452 | John Marshall | Sec. 5, T. 1 S., R. 4 W. | 1888 | 7-inch pipe | 1,128 | 1,103 | 42 | do | | | Small. | Do. |
| 453 | I. W. Hazlett | Sec. 4, T. 1 S., R. 4 W. | 1900 | do | 1,101 | 1,082 | 142 | 12 wind | 238 | | .002 | Do. |
| 454 | Mrs. Alice Wixom | do | | do | 1,067 | 1,055 | 22 | do | | | Small. | Do. |
| 455 | Mrs. Irving | do | | do | 1,099 | 1,078 | 100 | 8 wind | | | Small. | Do. |
| 456 | J. B. Kitring and R. H. Hacker. | do | 1895 | 2-inch pipe | 1,085 | (a) | 152 | do | | 260 | Small. | Do. |
| 457 | J. F. Cadd | do | 1888 | 7-inch pipe | 1,068 | 1,057 | 40 | Hand | 40 | | Small. | Do. |
| 458 | H. E. Gardner | Sec. 5, T. 1 S., R. 4 W. | | 3-inch pipe | 1,089 | 1,075 | | 8 wind | | | Small. | Do. |
| 459 | Mrs. Marilla Smith | do | 1889 | 2-inch pipe | 1,094 | 1,079 | 122 | Wind | 122 | 150 | Small. | Do. |
| 460 | San Bernardino County Hospital. | Sec. 8, T. 1 S., R. 4 W. | 1898<br>1899<br> | 3-inch pipe<br>7-inch pipe<br>10-inch pipe | 1,089 | 1,071 | 125<br>125<br>330 | Centrifugal; 6 gas | | | .300 | Irrigation. |
| 461 | | do | | 2 wells | 1,057 | | | Electric | | | | Do. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 462 | Riverside Trust Co. | Sec. 26, T. 1 S., R. 4 W. | | 9 wells | 1,019 | 1,019 | | Artesian | | | | 1.976 | Do. |
| 463 | Riverside Water Co. | Sec. 2, T. 1 S., R. 4 W. | | | 1,036 | 1,036 | | do | | | | 1.930 | Do. |
| 464 | do | do | | | 1,037 | 1,037 | | do | | | | 2.896 | Do. |
| 465 | do | do | 1900 | 10-inch pipe | 1,040 | 1,040 | 544 | do | | | | 3.096 | Do. |
| 466 | do | do | 1900 | do | 1,041 | 1,041 | 582 | do | | | | .200 | Do. |
| 467 | E. D. Meissner | Sec. 26, T. 1 S., R. 4 W. | 1899 | 10 and 8 inch pipes | 1,200 | 1,120 | 500 | Plunger pump; 20 gas | 2,600 | 1,850 | | .008 | Domestic; irrigation. |
| 468 | G. G. Lathrop | do | 1897 | 7-inch pipe | 1,063 | 1,017 | 70 | 10 wind | 105 | 130 | | | Domestic. |
| 469 | R. L. Dewitt | do | 1897 | Dug | 1,047 | 1,028 | 26 | Hand | | | | .007 | Irrigation. |
| 470 | Charles Morris | do | 1892 | Dug, 12 by 12 foot, 10-inch pipe. | 1,078 | 1,063 | 80 | 12 wind | 400 | 140 | | .005 | |
| 471 | do | do | 1899 | 10, 8, and 7 inch pipes. | 1,077 | | 640 | Artesian | 1,500 | | | | |
| 472 | No record. | | | | | | | | | | | | |
| 473 | F. S. Waters | Sec. 23, T. 1 S., R. 4 W. | 1877 | 2-inch pipe | 1,054 | 1,044 | 196 | 8 wind | 200 | 145 | | .002 | Domestic; irrigation. |
| 474 | J. H. Hatherley | do | 1888 | 3-inch pipe | 1,555 | | 450 | Artesian | 1,700 | | | .140 | Irrigation. |
| 475 | J. H. Kelly | do | 1890 | 8-inch pipe | 1,089 | | 382 | do | 2,000 | | | .400 | Domestic; irrigation. |
| 476 | do | do | 1891 | 7-inch pipe | 1,074 | 1,066 | 500 | Hand | | 5 | | | Domestic. |
| 477 | Mr. Meyers | Sec. 25, T. 1 S., R. 4 W. | 1890 | do | 1,060 | | 400 | | | | | (b) | |
| 478 | W. E. Pedley | Sec. 2, T. 1 S., R. 4 W. | 1899 | 10-inch pipe | 1,042 | | 510 | Artesian | 1,284 | | | 2.700 | Irrigation. |

a 1,070 feet in 1899.

b Stopped flowing in 1899.

# INDEX.


A.

Page.

Absorption of flood waters, rate of 50, 51
Alkali lands, cause of, by cienagas 47
Alluvial cones in San Bernardino Valley 36
Alluvial fan near Kenwood, plate showing 34
section of 36
showing drained prism 72
Alluvial fans, artesian conditions of 56
character of soils in 21
formation of 35–38, 44
Alluvium, absorptive quality of soils of 22
change in character of, conditions of 44
character of, in Santa Ana Valley 38, 39
effect of character of, on underground flow 28
formation of, from two uplifts 43
in San Bernardino region 33
preservation of trees in 46
temperature in, rise of 75
time required for deposit of 46
*See also* Earlier alluvium; Later alluvium.
Altitudes in San Bernardino Valley 31
Anaheim, water level near, chart of 63
water plane at 60, 61
Analyses of waters 77–79
Antill tract, wells in 41
well in, flow of 53
Apricots, cultivation of 23
growth of 16
Aridity, advantages of 17
effect of, on débris accumulation 35
Arrowhead springs, temperature of 73
water from, analysis of 78
Artesian area, decrease of 29, 62
Artesian areas in San Bernardino Valley 29–67
outside of San Bernardino Valley 67–71
plate showing Pocket.
Artesian pressure, decrease of 62
Artesian water, discovery of 29
in earlier alluvium 42
in San Bernardino Valley 29–67
origin of head for 52–56

B.

Page.

Badlands, cause of, by uplift 30
hot wells in 42
Baldwin Lake, plate showing 12
Barley, cultivation of 16
Bear Valley dam, construction of 11
Bench lands, agricultural value of 17
value of, recognition of 11, 12
Bibliography of irrigation for San Bernardino Valley 13
Binnie, Alexander R., cited on average rainfall 18
Bowlders, movement of, by storm waters 37
Box S springs, form of, from a cienaga 48
Bucher well, section of 38
Bunker Hill, mission settlement near 10
Bunker Hill dike, checking of floods at 65
effect of, on underground water 26
formation of 30
hot waters near, origin of 76
plate showing 72
stoppage of underflow by 52

C.

Cajon Pass, fault in 30
Calcium carbonate, effect of, from evaporation 48
California, southern, map of 8
soils in, classification of 20–23
Canals above Colton, measurement of water in 86, 87
Cement gravel and sand, occurrence of 37
Chemical character of waters 76–79
Cienaga, peat from the 41
Cienagas, artesian conditions indicated by 47
cause of 47
evaporation from, effect of 47
supply of water from 29
Citrus fruits, bench lands adapted to 11
production of, growth of 12
City Creek, discharge of, measurement of 83
Clapp, W. B., measurement of streams by 50
Clay, deposition of, from two uplifts 43
in San Bernardino region 33
occurrence of, in artesian area 38, 39

Page.

Canal, flooding of, in San Bernardino Valley ..... [illegible]
Canal, canal, measurement of water in ..... [illegible]
Canals, records of ..... [illegible]
water flowing and diverted, amount measured of ..... [illegible]
Cantaloupes in San Bernardino region ..... [illegible]
Carter, F. M., analysis of water furnished by ..... [illegible]
Carter canal, discharge of, measured at ..... [illegible]
Carter, H. A., work in charge of, section across ..... [illegible]
Cement-rock, occurrence of ..... [illegible]

D

Dam, construction of, across Santa Ana River ..... [illegible]
Dam, effect of, on water supply ..... 64
need of, to distribute water supply ..... 67
Deltas, formation and accumulation of ..... 36
Denver basin, Colo., wells in, 5 w of ..... 66
Depositions, conditions of, change of ..... 44
time required for ..... 46
Diorites in San Bernardino region ..... 32
Discharge of Santa Ana River, measurement of ..... 25, 28
Discharge measurements, tables of ..... 79–87
Drainage in alluvial fan, section showing form of ..... 72
Dunlap ranch, wells on ..... 67

E.

Earlier alluvium, amount of water reaching ..... 44
area of, favorable to water supplies ..... 69, 70
artesian water in ..... 42
character of ..... 42, 69
origin of ..... 43
view of ..... 68
water in ..... 68
water-bearing character of ..... 35
wells in ..... 42–44
East Riverside mesa, plate showing ..... 16
East Twin Creek, discharge of, measurement of ..... 84
El Casco, earlier alluvium at, water in ..... 69
Eldridge, G. H., cited on wells in Denver basin ..... 66
Evaporation, loss by ..... 61
Experiment Stations, Office of, bulletins on irrigation published from ..... 14

F.

Fans, alluvial. *See* Alluvial fans.
Faults, hot springs caused by ..... 73
Fault, occurrence of, in San Bernardino region ..... [illegible]
see also Uplift.
Fond waters in Santa Ana River, discharge of ..... [illegible]
rates of accretion of ..... [illegible]
Floods, control of ..... [illegible]
effect of, on alluvial fan deposits ..... [illegible]
Flow in streams and canals, tables of ..... [illegible]
Flowing water, decline of, cause of ..... [illegible]
Fossils, influence of, on stream flow ..... [illegible]
geologic age of ..... [illegible]
Fossils in San Bernardino Valley ..... [illegible]
Frank Brothers' well, section of ..... [illegible]
Fruits in San Bernardino Valley ..... [illegible]

G.

Gage, Matthew, construction of canal by ..... [illegible]
Gage canal, use of artesian water by ..... [illegible]
artesian wells of ..... [illegible]
Gage Canal Company, measurements of ..... [illegible]
Gage canal system, thermal waters of ..... 73
water from, analyses of ..... 77
wells of, records of ..... 54
flow of ..... 52
interdependence of ..... 54
Geologic history of San Bernardino Valley ..... 33, 34
Glauber's salt in spring waters ..... 79
Gneisses in San Bernardino region ..... 32
Gravels, extensive deposit of, conditions of ..... 46
extensive occurrence of, under Victoria tract ..... 46
in San Bernardino region ..... 35
movement of water through, rate of ..... 48, 49, 50
Ground waters, location of ..... 71
of San Bernardino Valley ..... 71–72
origin of ..... 71

H.

Hall, W. H., work of, on irrigation in southern California ..... 13
Hamlin, Homer, cited on rates of underflow ..... 49–50
rates of underground flow measured by ..... 28
Hardpan, occurrence of ..... 37
Harlem Springs, temperature of ..... 74, 76
water from, analysis of ..... 79
Heads of water for artesian flow, origin of ..... 52–56
hypotheses for ..... 53
Heated waters, origin of ..... 72, 73
Highlands ditch, construction of ..... 11
Hilgard, E. W., analyses of water by ..... 77, 78
cited on subterranean water in San Bernardino Valley ..... 54

Page.
Hilgard, E. W., dams suggested by 67
paper by, on subterranean water supply of San Bernardino Valley 14
History of settlement of San Bernardino Valley 10–12
History, geologic, of San Bernardino Valley 33–34
Hobo well, rise of temperature in 74
Hot springs, crust movement marked by 73
distribution of 72, 73
medicinal use of 78
origin of 72, 73

I.

Impervious beds, effect of 52
Irrigated lands, hydrologic map showing Pocket.
Irrigation, bibliography of, for San Bernardino Valley 13
development of, in San Bernardino Valley 10–12
effect on, of diminished water supply 56, 57
first use of, in San Bernardino Valley 10
improvement in practice of 12
need of 67
increase of discharge of Santa Ana River by 28
return waters from 26
Irving, William, paper by, on duty of water under Gage canal 14

J.

Johnson, A. K., analysis of waters by 77
Johnson, Gudeman, record of water level kept by 59
Johnson well, water level in, chart of 62

L.

Later alluvium, origin of 43
plates showing 34
water-bearing character of 35
wells in 38–41
Lippincott, J. B., estimate by, of water stored in San Bernardino Valley 65
papers by, on water supply of San Bernardino Valley 13, 14
Los Angeles, underflow near, rates of 49, 50
Los Angeles River, subsurface flow measured near 28
Lugo family, lands in San Bernardino Valley owned by 10
Lytle Creek, discharge of, measurement of 85
Lytle Creek wash, wells in 41
Lytle Creek wells, waters from, analysis of 77

M.

Map showing changes in artesian areas and water levels Pocket.
Map, hydrologic, of San Bernardino, Redlands, and vicinity Pocket.
Map, outline, of southern California 8
Marbles in San Bernardino region 32
Mesas, soils on, character of 22
use of, for citrus industry 12
Mill Creek, discharge of, table of 79, 80
Mill Creek zanja, construction of 10
Mission settlements in San Bernardino Valley 10
Mohave Desert, mountains in, effect of aridity on 35
Mohave River, underflow near, measurement of 49
underflow near, rates of 28
Mormons, settlement of, in San Bernardino Valley 10

N.

Neff, J. B., water plane at Anaheim determined by 60, 61
Neff well, water levels in, chart showing 63

O.

Oats, cultivation of 16
Older alluvium. *See* Earlier alluvium.
Olive trees, growth of 16

P.

Payne well, temperature of 74, 76
water from, analysis of 77
Peat, occurrence of, in well section 41
Percolation, rates of 28, 48, 49, 50
Physiography of San Bernardino Valley 33, 34
Plunge Creek, discharge of, measurement of 83
Pockets in old river deposits, occurrence of 38
Politana, mission settlement at 10
Precipitation. *See* Rainfall.
Pumping, increased need of, with lowering water level 56
limit of profit in 65
necessity of, for ground waters 71

Q.

Quartz-porphyry in San Bernardino region 32

Page.

R.

Rainfall, amount of, required under present conditions 67
at Colton, records of 16
at Redlands 17
at San Bernardino 18
chart showing 19
average of 18, 64
in San Bernardino Valley 15–20
effect of, on water level 29
necessary amount of 62
relation of, to water plane 59
results of 24, 25
run-off compared with 24
time of occurrence of 23
in southern California, distribution of, cause of 15
Redlands, hydrologic map of Pocket.
plate showing 20
rainfall records at 17
water supply of 67
Redlands quadrangle, water level in, change of 57
wells in, list of 87–99
Redlands Water Company, wells of, not flowing 42
Redlands wells, origin of water of 69
Reservoir street canyon, origin of 69
Return waters, quantity of, variation in 26
uncertainty of 64
Riverside, gravels near, character of 70
water supply of 71
wells above, head of 70
Riverside basin, artesian water in 70
capacity of 71
Riverside canals, construction of 10
Riverside Narrows, flowing well near 70
Riverside Water Company, use of artesian water by 29
wells of 39
flow of 53
Riverside-Highlands irrigation district, plate showing 12
Riverside Highlands Water Company, formation of 11
wells of 39
Rocks, classification of, in San Bernardino Valley 32
Run-off, effect of forests on 24, 25

S.

San Bernardino, average rainfall at 64
average rainfall at, chart showing variation from 19
hydrologic map of Pocket.
rainfall records at 18
water level near, chart of 62
San Bernardino and San Gorgonio peaks, plate showing 20
San Bernardino artesian area 29–67
San Bernardino basin, depth of 31
location of 9
origin of 30, 31

Page.

San Bernardino basin, quantity of water obtained from, above Colton 1[illegible]
water level in, map of changes of Pock[illegible]
San Bernardino mission, growth of [illegible]
San Bernardino Mountains, formation of [illegible]
San Bernardino quadrangle, water level in, change of [illegible]
wells in, list of 10[illegible]–[illegible]
San Bernardino Valley, aridity in, effect of [illegible]
forest growth in, value of [illegible]
formation of, by crustal movements [illegible]
head of water in 32–[illegible]
irrigation in 10[illegible]
mission settlements in [illegible]
old topography of [illegible]
rainfall in 15–[illegible]
rocks in, classes of 32–[illegible]
section across [illegible]
settlement in [illegible]
stream and canal flow in, tables of 79–[illegible]
temperature of waters in 72–[illegible]
underflow in [illegible]
water from, analyses of [illegible]
water plane in, attitude of [illegible]
water stored in [illegible]
water supply of 23–[illegible]
conclusions on [illegible]
papers relating to 13, [illegible]
well sections in 40, 42, [illegible]
San Diego, rainfall below average at [illegible]
San Gorgonio Pass, fault in [illegible]
San Timoteo Canyon, earlier alluvium near [illegible]
flowing wells in [illegible]
view of [illegible]
Sand dunes, formation of, affecting alluvial fans [illegible]
Sands in San Bernardino region [illegible]
Sandstone in San Bernardino region [illegible]
Santa Ana basin, table of discharge of, above Colton [illegible]
Santa Ana River, alluvium near, character of 38–[illegible]
discharge measurements of [illegible]
28, 81, [illegible]
drainage system of, importance of [illegible]
flow in, nature of [illegible]
hot springs near [illegible]
sinking of flood waters in, diagram of [illegible]
soils produced by [illegible]
underground flow of, effect of [illegible]
volume of, increase in [illegible]
Santa Ana Valley, nonartesian lands in, plate showing [illegible]
plate showing [illegible]
Santa Ana wash, dams across [illegible]
underflow in, rate of [illegible]
Savannah, Ga., wells at, failure of [illegible]

Page.
Schists in San Bernardino region 32
Section across Crafton Hills and Yucaipe Valley 68
across San Bernardino Valley 32
of alluvial fan 36
showing drainage 72
of Bucher well 38
of water table under stream channel 49
of well in Yucaipe Canyon 44
in Yucaipe Valley 43
of wells in San Bernardino Valley 40, 42
Seepage, rates of 28, 48, 49, 50
Settlement in San Bernardino Valley 10
Shales in San Bernardino region 33
Shedd, J. A., analysis of waters by 77
Silk Center Association, work of, in San Bernardino Valley 10
Singleton wells, origin of water in 69
Slichter, C. S., cited on motions of underground waters 28, 49, 66
Soils, absorptive capacity of 22, 23
classification of, in southern California 20–23
varieties of, in San Bernardino Valley, origin of 21
South Mountain Water Company, well of, section of 43
Spring Brook, artesian wells near 70
Springs, origin of, by leakage through clay 56
Storms, effect of, on alluvial-fan deposits 44, 45
movement of material by 37
Strata, variation of, in alluvium 39–41
Stream channel, section of water table beneath 49
Streams, influence of forests on 24, 25
Subsoil, importance of 22

T.

Temperature, rate of rise of, with increase of depth 75
Temperatures in waters, origin of 72, 73
in wells, table of 74
of waters in San Bernardino Valley 72–76
Thermal waters, origin of 72, 73
Toumey, J. W., cited on relation of forests to stream flow 24
Trees, preservation of, in alluvium 46

U.

Underground circulation 48–51
Underground flow, rates of 28, 48, 49, 50
Underground waters not artesian 71, 72
use of, on citrus lands 11
*See also* Artesian waters.
Uplift, effects of, on land surface 43
faults and hot springs caused by 73
Urbita Hot Springs, water from, analysis of 78
Urbita Springs well, temperature of 74

V.

Victoria tract, extensive gravel beds beneath 46
well on, measurements of 59
Vineyards, growth of, on sandy lands 16

W.

Warm Creek, flow in, decrease of 64
springs near 56
water from, analysis of 77
Water, amount of, stored in valley 65
flowing and developed above Colton 63
in San Bernardino Valley above Colton, quantity of 13
tables of flow of 79–87
Water-bearing beds, connection of 53, 56
Water-bearing formations, character of 35
Water level, change of, in Redlands quadrangle 57
change of, in San Bernardino basin, map showing Pocket.
decline of, at Anaheim 60–63
in Williams well 59
chart showing 60, 61
in Johnson well 59
in Johnson well, chart of 62
in Neff well, chart of 63
in San Bernardino quadrange, change of 58
Water plane, at Anaheim 60, 61
altitude of, in San Bernardino Valley 48
changes of 50
lowering of 29
effect of 56, 57
relation of, to rainfall 59
Water supply, conclusions from discussion of 67
decline of 56–67
decrease of, in wells, cause of 66
in San Bernardino Valley 23–28
limit to prudent use of 65
source of 12, 23
Water table, section of, under stream channel 49
Waterman Canyon, hot springs in 73
Waters, chemical character of 76–79
Waters, hot, medicinal use of 78
origin of 72, 73
Well records of Gage canal system 54
in San Bernardino Valley 38–46
Well section in Yucaipe Canyon 44
in Yucaipe Valley 43
Well sections in San Bernardino Valley 40, 42, 45

Page.

Wells, change of water level in, in San Bernardino quadrangle ---------- 58
failure of, cause of---------- 66
flowing, occurrence of---------- 42
hot, occurrence of---------- 42
in Redlands quadrangle, change of level in---------- 57
kind, depth, cost, etc----- 87–99
in San Bernardino quadrangle, kind, depth, cost, etc. 100–117
temperatures of, table of------ 74
West Riverside district, plate showing ---------- 14
West Twin Creek, discharge of, measurement of------ 84
Williams well, record of water level in ---------- 59
variation of water level in, chart showing------- 60, 61
Woodbridge, Professor, analysis of water by---------- 70

Y.

Yucaipe basin, artesian water in--- 67–70
Yucaipe Canyon, water in--------- 6[illegible]
well section in---------- 44
Yucaipe Valley, section across----- 6[illegible]
view of---------- 70
well section in---------- 43
wells in---------- 42

O

# PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 142.]

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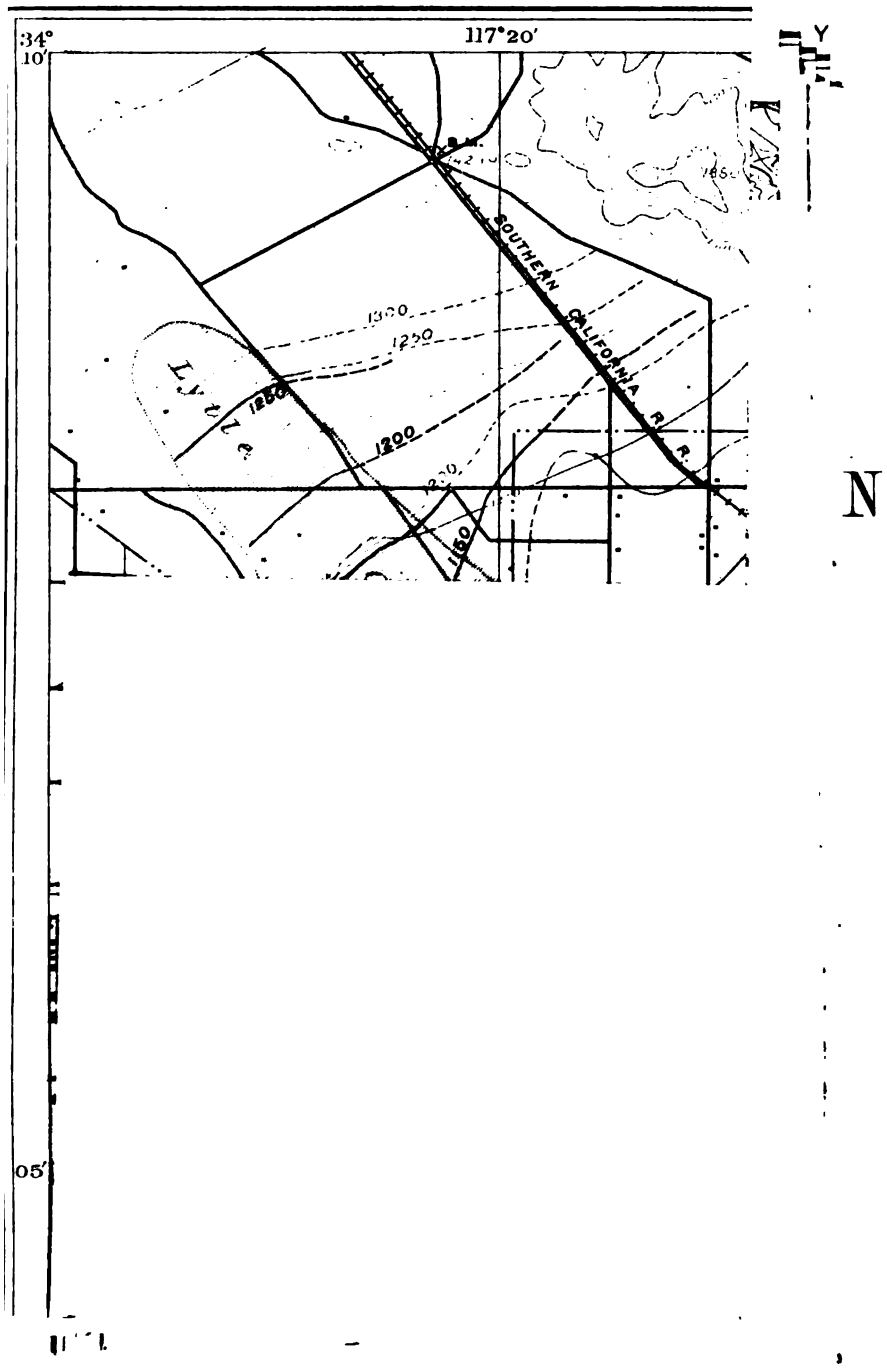

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

# EXPERIMENTS

ON

# STEEL-CONCRETE PIPES ON A WORKING SCALE

BY

JOHN H. QUINTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1905

# CONTENTS.


| | Page. |
|---|---|
| Letter of transmittal | 7 |
| Introduction | 9 |
| Steel pipe | 9 |
| Wooden pipe | 10 |
| Steel-concrete pipe | 11 |
| Composition and construction of pipes | 11 |
| Composition of test pipes | 13 |
| Pipe No. 1 | 13 |
| Pipe No. 2 | 13 |
| Pipe No. 3 | 14 |
| Pipe No. 4 | 14 |
| Pipe No. 5 | 14 |
| Pipe No. 6 | 14 |
| Pipe No. 7 | 15 |
| Method of pipe construction | 15 |
| Apparatus used for testing pipes | 17 |
| Tests | 18 |
| Pipe No. 1 | 18 |
| Plaster linings | 18 |
| Test 1 | 19 |
| Test 2 | 21 |
| Pipe No. 2 | 21 |
| Plaster linings | 21 |
| Test 1 | 22 |
| Test 2 | 23 |
| Test 3 | 24 |
| Test 4 | 25 |
| Pipe No. 3 | 28 |
| Test 1 | 28 |
| Test 2 | 28 |
| Test 3 | 31 |
| Test 4 | 32 |
| Test 5 | 32 |
| Pipe No. 4 | 35 |
| Test 1 | 35 |
| Test 2 | 36 |
| Pipe No. 5 | 38 |
| Test 1 | 38 |
| Test 2 | 38 |
| Test 3 | 40 |
| Pipe No. 6 | 41 |
| Test 1 | 41 |
| Test 2 | 41 |
| Test 3 | 42 |

Tests—Continued.
Pipe No. 7
Test 1
Test 2
Summary of first 19 tests
Pipe No. 8
Composition
Test 1
Small pipes
Pipe A, Mixture No. 1
Pipe B, Mixture No. 1
Pipe C, Mixture No. 1
Results of tests of small pipes
Conclusions
Index

# ILLUSTRATIONS.


| | | Page. |
|---|---|---|
| PLATE I. | *A* and *B*, Method of pipe construction | 14 |
| II. | *A*, Method of finishing pipe; *B*, Pipe with disks set ready for test | 16 |
| III. | Details of disk and central rod | 18 |
| IV. | *A*, Pipe under test; *B*, Method of raising end of pipe | 20 |
| FIG. 1. | Diagrammatic section of pipe, showing directions of tamping | 16 |
| 2. | Sections of pipe, showing methods of connection | 47 |
| 3. | Elevation of end of small pipes, with cover, used for determining permeability of different mixtures of concrete | 50 |
| 4. | Horizontal section of small pipes used for determining permeability of different mixtures of concrete | 51 |

# LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
*Washington, D. C., March 25, 1905.*

SIR: I transmit herewith a manuscript by John H. Quinton, supervising engineer of the Reclamation Service, entitled "Experiments on Steel-Concrete Pipes on a Working Scale," and request that it be published as one of the series of Water-Supply and Irrigation Papers.

The use of concrete as a substitute for stone and metal in connection with engineering projects has, during the last few years, become well-nigh universal. One of the most important fields of engineering investigation is that of determining the durability and permanence of concrete structures, especially those erected in connection with water supplies. The investigations reported in the accompanying manuscript are therefore of peculiar significance, and the results promise to be of great value.

Mr. Quinton's experiments have been made upon large pipes, and the results are therefore applicable for use in practical engineering work. Heretofore similar investigations have been made on a small scale, and the conclusions which have been drawn from them are, as shown in the accompanying paper, erroneous in many respects.

Very respectfully,

F. H. NEWELL,
*Chief Engineer.*

Hon. CHARLES D. WALCOTT,
*Director United States Geological Survey.*

# EXPERIMENTS ON STEEL-CONCRETE PIPES ON A WORKING SCALE.

By JOHN H. QUINTON.

## INTRODUCTION.

Preliminary surveys of many irrigation projects in the arid States have shown that pressure pipes or, as they are often called, "inverted siphons," will be necessary for the economical construction of some of the works contemplated by the Reclamation Service. Hitherto such pipes have been made of iron or steel, or of wood staves bound with iron or steel rods. During the last few years the manufacture of steel has been so improved that steel has entirely replaced iron in all important structures. Therefore the choice of material for pressure pipe has been limited to the two materials, steel and wood.

In all of the reclamation projects it is most important that the structures on the main canals shall be of a permanent nature. The works have to be maintained for several years by the Reclamation Service before they are turned over to the people of the district. They are to be paid for in ten annual installments, and at the end of ten years they should be in good repair and as sound and durable as when they were constructed. This condition is a difficult one to fulfill.

## STEEL PIPE.

Steel pipe is naturally limited to a thin shell on account of its great strength, weight, and cost. It is easily attacked by salts and acids, both on the inside by the water flowing through it and on the outside by the material surrounding it. A slight deterioration in so thin a shell means a large loss in strength, and the life of a steel pipe is therefore limited to a few years, depending upon the nature of the material in which it is laid. Experience has shown that in alkali ground in southern California the life of sheet-steel pipe is short. The life of the pipe may be lengthened by a coating, both inside and outside, of asphaltic material. The coating is applied by dipping the pipe into a hot bath of the asphalt mixture. If this dipping is not carefully done at just the proper temperature it is not likely to add

much to the life of the pipe. The coating is liable to be broken in places by careless handling in transit from the factory to the work, and unless such places are recoated they are soon attacked, and the efficiency of the pipe is thus materially lessened. In all of the projects in the arid States more or less alkali ground is encountered, and in many of the projects provision has to be made for the drainage of the lands to get rid of the alkali. Under these circumstances other and more durable material than steel or iron must be sought.

## WOODEN PIPE.

Wooden pipes are now very extensively used for carrying water under pressure, and they have many advantages over steel. Large wooden pipes, however, must necessarily be made of longitudinal staves, bound and held in place by steel rods on the outside. The wood is porous and is soon filled with the water under pressure, and this makes the wooden part of the pipe practically safe from decay when it is protected from the rays of the sun either by a layer of earth or a light roof. The pipe must be filled with water at all times, however, to maintain the condition of saturation which is necessary for its durability. In a cold climate, such as that found in Montana, Wyoming, and the Dakotas, it would be unwise to keep a pipe full of water in the winter time when it is not in use for irrigation. Freezing weather would certainly affect the pipe injuriously unless it were buried in the ground deep enough to be unaffected by frost. The entire bursting strength of a large wooden pipe is derived from the steel bands or rods with which it is bound, and these, when buried underground, are then exposed to the same destructive agencies which attack the steel pipe. The form of the bands, however, being generally circular in section, gives them a longer lease of life than the thin shell of metal in a steel pipe; for this reason a wooden pipe is certainly a great improvement on a steel pipe.

Wooden pipes also have their limitations. They are fragile and easily broken by a blow from the outside and should never be used where they may be exposed to falling rocks or small landslides. If they are laid on the surface and exposed to the rays of the sun, the wood in the upper half of the pipe soon decays from alternate wetness and dryness, caused by different temperatures in sunshine and shade. In the heat of the sun the upper part of the pipe is dried rapidly, and during the night the pressure and capillary action force the water to the surface, to be dried out again the next day. This action may be counteracted in warm climates by building a roof over the pipes, but in cold climates the pipe must be emptied before frost sets in and allowed to remain empty all winter. This, again, subjects the pipe to alternate wetness and dryness, although at longer intervals; it also allows the staves to shrink in the winter time, and when the water is

turned into the pipe, and before the wood has had time to swell, sand and grit are forced into the seams between the staves, and the pipe becomes leaky and unserviceable.

In view of all these conditions, it was thought advisable to examine into the merits of steel concrete as a material for pressure pipes in the place of steel or wood.

## STEEL-CONCRETE PIPE.

There is little doubt that steel concrete is a much more durable material than either steel or wood, but at the very outset it presents a serious drawback. Concrete is porous; and while theoretically it might be composed of such material as would render it impervious to water under ordinary pressures, practically it is found to be very difficult to make it so.

Many statements have been made as to the waterproof qualities of certain mixtures for concrete, but water under pressure is a very searching agent, and it must be admitted that so far as these experiments have gone such statements have not been substantiated. To determine just how much pressure of water ordinary well-made concrete would stand without leaking seriously, and what mortars would most effectually stop leaking, and up to what pressure, these experiments were undertaken.

It was recognized that experiments with small pipes would not be of such practical value as those with pipes of sizes more nearly commensurate with the work in hand. It was finally decided to make seven or eight pipes, each 5 feet in diameter inside and 20 feet long, with a 6-inch thickness of concrete shell, inclosing an armor of steel rods sufficient to resist a head of 150 feet of water with a factor of safety of 4. The quantities of water to be carried in the different projects vary from 250 to 1,500 second-feet, and this size seemed as small as it would be advisable to experiment with in order to show the practical difficulties of construction, as well as the flaws and imperfections in the pipe arising from careless or defective workmanship.

Water under pressure tells the truth without fear or favor, and a careful reading of these pages will show that there are many practical difficulties to be overcome in the construction of steel-concrete pipe, and that the most careful attention to details and rigid inspection and supervision are necessary to produce a steel-concrete pipe that will stand 100 feet of head of water without appreciable leakage.

## COMPOSITION AND CONSTRUCTION OF PIPES.

Experience with concrete structures has shown that with nearly all kinds of cement there is an efflorescence deposited on the surface of the concrete wherever there is sufficient water back of the wall to force this efflorescence to the surface. This is due to the permeability of

the concrete and the passage of the water through it. Small particles of lime or cement are carried to the surface and deposited in the form of white powder.

There is also found in concrete a pulpy, gelatinous fluid, called by the French "laitance," from its milky appearance. Whenever water is forced through concrete this substance is deposited freely on the surface.

The entire subject of porosity and permeability of mortar and concrete has been very ably treated by M. R. Feret, chief of the Boulogne laboratory of the Ponts et Chaussées, in a paper published in the Annales des Ponts et Chaussées, July, 1892, and a most interesting discussion of the subject by American engineers is to be found in the Proceedings of the American Society of Civil Engineers, vol. 29, No. 6. In this discussion Mr. R. W. Lesley suggested that an addition of slaked lime to the concrete of which the pipe is composed might aid in making the mortar impermeable. Some of the pipes tested have been made with this addition. Mr. Lesley also referred to a paper by Messrs. J. B. McIntyre and A. L. True on The Permeability of Concrete under High Water Pressures. Some of the conclusions drawn from the experiments made by these gentlemen are, however, rather sweeping.

In the second paragraph of these conclusions it is stated that concretes composed of mixtures of cement, sand, and rock in the proportions of 1:2½:4 were impermeable under heads varying from 20 to 80 pounds per square inch, and in the last paragraph the following statement is made:

> It is perfectly safe to conclude that a concrete of the proportions of any of the specimens which did not leak under 80 pounds pressure would be practically impermeable under any condition ordinarily found in practice.

This seems a rather hasty conclusion, as the following pages show that many of the conditions ordinarily found in practice render it almost impossible to make a long and large concrete pipe impermeable. It is far from the intention of the writer to belittle in any way laboratory experiments, but great care must be exercised in drawing conclusions, especially in generalizing from particulars.

To determine just how a steel-concrete pipe, made by ordinary workmen in the usual practical way, would act under pressure was one of the main objects of these experiments.

It was decided to make seven pipes, with different proportions of sand, gravel, cement, lime, and waterproof material, with steel armor sufficient to resist a head of 150 feet of water, with a factor of safety of 4, under such conditions as would be found in most of the projects under consideration by the Reclamation Service, these conditions being well understood by the writer, who had visited the various localities and was familiar with them. It was not intended or supposed that

the experiments would cover a range great enough to exhaust the subject of impermeable concrete or mortar, but it was presumed that they would indicate the best mixtures and the limit of pressure which it would be wise to fix for actual work in the field, where pipes may be 3,000 or 4,000 feet in length and of large diameter.

## COMPOSITION OF TEST PIPES.

The composition and dimensions of the test pipes are given below. All measurements were made loose, in boxes, just as they would probably be made in the field. These pipes were all made by workmen skilled in making concrete, who had been employed by a concrete contractor in Los Angeles. The work was supervised by the writer and by Mr. W. H. Sanders, consulting engineer of the Reclamation Service, one of whom was present at all times during the construction of the pipes.

### PIPE No. 1.

Inside diameter, 5 feet; length, 20 feet; thickness, 6 inches; steel armor, 71 welded rings of three-fourths-inch round steel, and eight longitudinal steel rods one-half inch in diameter. In all pipes except No. 7 the armor was placed in the center of the shell.

*Material used for concrete for pipe No. 1.*

| | Parts. |
|---|---|
| Cement, Gillingham | 1 |
| Sand—clean river sand—fine to coarse | 2 |
| Gravel refused on screen of 1¼-inch mesh and passing through 2½-inch mesh | 2.5 |
| Gravel refused on screen of half-inch mesh and passing through 1¼-inch mesh | 2.5 |
| Water | 1.1 |

In this pipe 169 cubic feet of concrete in place required 214 cubic feet of solid materials, measured loose, or 243.2 cubic feet of solids and liquid. This pipe required 0.88 barrel of cement to one cubic yard of concrete.

### PIPE No. 2.

Dimensions and armor same as No. 1.

*Material used for concrete for pipe No. 2.*

| | Parts. |
|---|---|
| Cement, Gillingham | 1 |
| Sand | 2 |
| Gravel refused on 1-inch mesh and passing through 2½-inch mesh | 1.6 |
| Gravel refused on half-inch mesh and passing through 1-inch mesh | 1.6 |
| Water | .8 |

In this pipe 169 cubic feet of concrete required 243.75 cubic feet of solid materials, measured loose. This pipe required 1.27 barrels of cement to 1 cubic yard of concrete.

### PIPE No. 3.

Dimensions and armor same as No. 1. Half of the water used in the construction of this pipe was mixed with soap in proportion of

one-half pound of soap to 1 gallon of water, and the other half was mixed with 1 pound of alum to 4 gallons of water. The materials are in the following proportions:

*Material used for concrete for pipe No. 3.*

| | Parts. |
|---|---|
| Cement, Ideal | 1 |
| Sand | 2 |
| Gravel, half-inch mesh | 3.2 |
| Water | 1 |

In this pipe 169 cubic feet of concrete in place required 234 cubic feet of solid materials, measured loose, or 272 cubic feet of solids and liquid. This pipe required 1.6 barrels of cement to 1 cubic yard of concrete in place.

PIPE No. 4.

Dimensions and armor same as No. 1.

*Material used for concrete for pipe No. 4.*

| | Parts. |
|---|---|
| Cement, Ideal | 1 |
| Sand | 2 |
| Gravel, all half-inch mesh | 4 |
| Water | .96 |

In this pipe it required 247 cubic feet of solids, measured loose, or 281 cubic feet of solids and liquid to make 169 cubic feet of concrete in place. This pipe required 1.4 barrels of cement to 1 cubic yard of concrete in place.

PIPE No. 5.

Dimensions and armor same as No. 1.

*Material used for concrete for pipe No. 5.*

| | Parts. | | | Parts. |
|---|---|---|---|---|
| Lime paste | 1 | or | Cementing material | 1 |
| Cement, Ideal | 2 | | Sand | 2 |
| Sand | 6 | | Fine gravel | 4 |
| Fine gravel | 12 | | | |

This pipe required 223 cubic feet of solids and paste, measured loose, to make 169 cubic feet of concrete in place. The amount of water used was not measured. This pipe required 0.84 barrel of cement and 81 pounds of lime paste to 1 cubic yard of concrete in place.

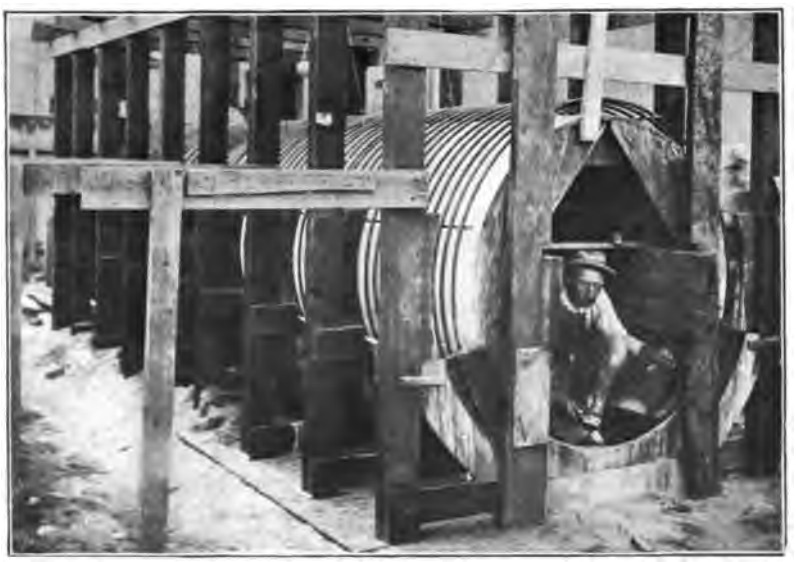
PIPE No. 6.

Dimensions and armor same as No. 1.

*Material used for concrete for pipe No. 6.*

| | Parts. | | | Parts. |
|---|---|---|---|---|
| Cement, Gillingham | 1 | or | Cementing material | 1 |
| Lime | 1 | | Sand | 2 |
| Sand | 4 | | Small gravel | 4 |
| Water | 2 | | Water | 1 |

*A*



*B*

METHOD OF PIPE CONSTRUCTION.

This pipe required 252 cubic feet of solids, measured loose, and 288 cubic feet of solids and liquid to make 169 cubic feet of concrete in place. It had 0.63 barrel of cement and 128 pounds of lime to 1 cubic yard of concrete in place.

PIPE No. 7.

Inside diameter, 5 feet; thickness of shell, 6 inches; length, 20 feet; steel armor composed of 41 pieces of half-inch, round, welded steel rod, held in place by 8 steel rods one-half inch in diameter and 20 feet in length. This armor is set 1¾ inches from inside of shell.

*Material used for concrete for pipe No. 7.*

| | Parts. | | | Parts. |
|---|---|---|---|---|
| Cement, Ideal | 1 | or | Cementing material | 1 |
| Lime paste | ½ | | Sand | 2 |
| Sand | 3 | | Small gravel | 4 |
| Small gravel | 6 | | | |

This pipe required 262 cubic feet of solids and paste to make 172 cubic feet of concrete in place. It was made with the intention of testing the elastic limit of the steel and concrete together as compared with the elastic limit of the steel alone, but it will be seen from a perusal of the experiments that this was impracticable on account of the leakage.

## METHOD OF PIPE CONSTRUCTION.

The method of construction shown in Pl. I may be briefly described as follows:

Nine rectangular frames of 4- by 6-inch rough pine lumber are first set up on the line of the pipe, about 2½ feet from center to center. These frames are about 7 feet in width inside and 8 feet in height.

The sills of these frames are cut out to the form of the lower seventh of the outside surface of the pipe, and are sunk into the ground until the upper ends of the arcs are even with the surface of the ground. The frames are then steadied and braced in their true line, and the material of the ground surface is removed to the form of the lower part of the outside surface of the pipe, as indicated by the buried sills.

Tarred paper is now laid over this surface to prevent undue absorption of moisture from the cement by the earth or by dry material.

A long sill is then laid on top of the frames on center line, as shown in Pl. I, *A*, and from this the steel armor is suspended and held in place by a few small blocks, which are removed as the concrete work reaches them. The wooden form for the inside surface of the pipe is now placed inside the pipe in four sections and nailed together with intersecting chord pieces to form the upper six-sevenths of the 5-foot circle. This form is then supported inside, in its true position, by two pieces of 2- by 12-inch plank the full length of the pipe and extending

beyond it at the ends. These planks are supported on two vertical pieces of 2- by 8-inch timber notched and held in place by spiking to the end frames.

This arrangement is exhibited in Pl. I, *B*, which shows the inside form and steel armor all ready for commencing the concrete work.

The first batch of concrete is laid on the tarred paper on the surface of the ground. This concrete has to be carried in buckets, and deposited quickly, and tamped through and under the steel armor for the full length of the pipe. Special tampers are made to fit between the rings and care is taken to keep the rings in their proper position until they are thoroughly covered with concrete. A wooden templet of the shape of the inside of the pipe is fixed at each end to guide the workmen in shaping the inside surface of the lower one-seventh of the

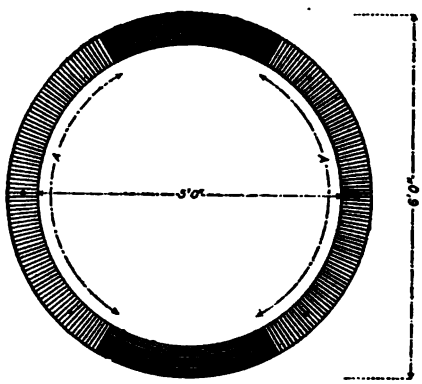



FIG. 1.—Diagrammatic section of pipe, showing directions of tamping.

pipe. This templet is plainly seen in front of Pl. I, *B*; the workman's trowel is pointing directly to it. The two lower sections of the outside form are also in place, so that as soon as the inside seventh of the pipe is completed the concrete can be run in and tamped from the outside and the work of laying it can be carried on continuously until the pipe is completed.

When the concrete has reached the top of these sections, another section of the outside form is added on each side, and so on until the upper part of the pipe is reached, where there is no longer any necessity for an outside form. The sections of the outside form are seen piled up in the foreground of Pl. I, *A*, and the method of fastening them to the outside frames is shown clearly in Pl. I, *B*.

The lower seventh of the pipe is tamped from the inside of the pipe in the direction of the pressure, and the upper eighth of the pipe is tamped from the outside in a direction opposite to that of the pressure. The remainder of the pipe (marked A, A, in fig. 1) is tamped in a direction normal to that of the pressure, or in what may be called a "circumferential direction."

*A.* METHOD OF FINISHING PIPE.

*B.* PIPE WITH DISKS SET READY FOR TEST.

The experiments show a marked difference in the degree of permeability of the concrete when tamped in these different directions.

All of the pipes were made on the same spot, as shown by framework in Pl. I, *A*, and when hard enough were rolled over to left and right alternately, to give room for the construction of the next pipe.

Each pipe was kept wet, both inside and outside, for at least one week after completion, and the last three pipes were, in addition, covered with canvas to protect them from the rays of the sun.

The concrete was all mixed by hand in the following way:

In the case of sand, cement, and gravel, the sand and cement, after loose measurement in boxes, was first shoveled over three times dry; the gravel was then added and the entire mass turned over twice dry and three times wet, the last time with a hoe. It was then shoveled into buckets and wheelbarrows and laid in the pipe, where it was thoroughly tamped. The buckets were used for the lower seventh of the pipe; the wheelbarrows were used for the sides and top of the pipe.

Pl. II, *A*, shows method of finishing upper part of pipe.

In the case of sand, cement, gravel, and lime paste (pipe No. 5) the paste was measured in boxes in the same way as the other materials, and the mass mixed just as before; but in the case of pipes Nos. 6 and 7 the lime paste was mixed with the water, and the lime water was used for wetting down the concrete during the process of mixing.

The work was all done in a careful and painstaking manner, as nearly as possible in the way in which it would be done on any ordinary piece of work in the field, under careful supervision and inspection. The first pipe of this series was completed on August 29, 1903, and the last pipe, No. 7, was completed on October 17, 1903. In the meantime all of the finished pipes were kept well wet, both inside and outside, so that they were thoroughly seasoned when the tests were commenced.

The pipes were all carefully squared up, and true planes were made at the ends with mortar composed of one part cement to one part sand, with a small quantity of lime paste to retard setting. This was done to make as perfect a joint as possible between the cast-iron ends used in testing and the pipe itself.

## APPARATUS USED FOR TESTING PIPES.

To fill the pipes with water and make the ends tight under pressure two cast-iron disks, with suitable reenforcing ribs, were made and held in place by steel rods passing through the pipe and both disks. The inside faces of these disks were perfectly smooth, plane surfaces, as shown on Pl. III.

To prevent leakage between the disk and the end of the pipe a ring of round rubber tire, 1¼ inches in diameter, was placed between the disk

and the shell of the pipe, and when the rods were tightened by the nuts at each end this gasket was flattened on the end of the pipe and formed a most effectual and tight joint under low pressures. It was found, however, that under high pressures the gasket was stretched at the joint, which was not vulcanized, and forced toward the outside of the pipe and caused leakage. To remedy this a ring of ½- by 1-inch bar steel was placed around the gasket and between the disk and the end of the pipe, and no further trouble arose here.

In Pl. II, *B*, one of the disks is clearly shown on the end of pipe No. 2. The pipe is all ready for testing. The small pipe to the left of the gage is designed to allow air to escape when the pipe is being filled, each pipe being raised at one end so that the air can be expelled before pressure is applied.

The connection to the right of and below the gage is for filling the pipe from the city water pipe in the yard. The pipe in the lower left-hand corner is connected with a pump for raising pressure above city water pressures. The large connection in the lowest part of the disk is for emptying the pipe. The eye in the upper part of the disk, to the left of the center, is for the purpose of holding the disk when the rods are being adjusted. Each disk weighs about 1,500 pounds, and was raised to its place by a differential pulley hung from the light frame shown at the farther end of the pipe.

The disk at the farther end of the pipe is exactly similar and symmetrical with the one shown, but has no pipe connections, as they are not needed.

Pl. IV, *A*, shows another pipe under test with pump and hose complete.

Pl. IV, *B*, shows the method of raising the pipes at one end after they had been rolled to one side.

Each pipe weighed about 10 tons, and had to be raised with jack-screws and a sling of manila rope, as it was found impracticable to raise it by wedging, the material of the pipe being easily injured at the ends, where it was needed in perfect condition to allow a tight joint between disk and pipe.

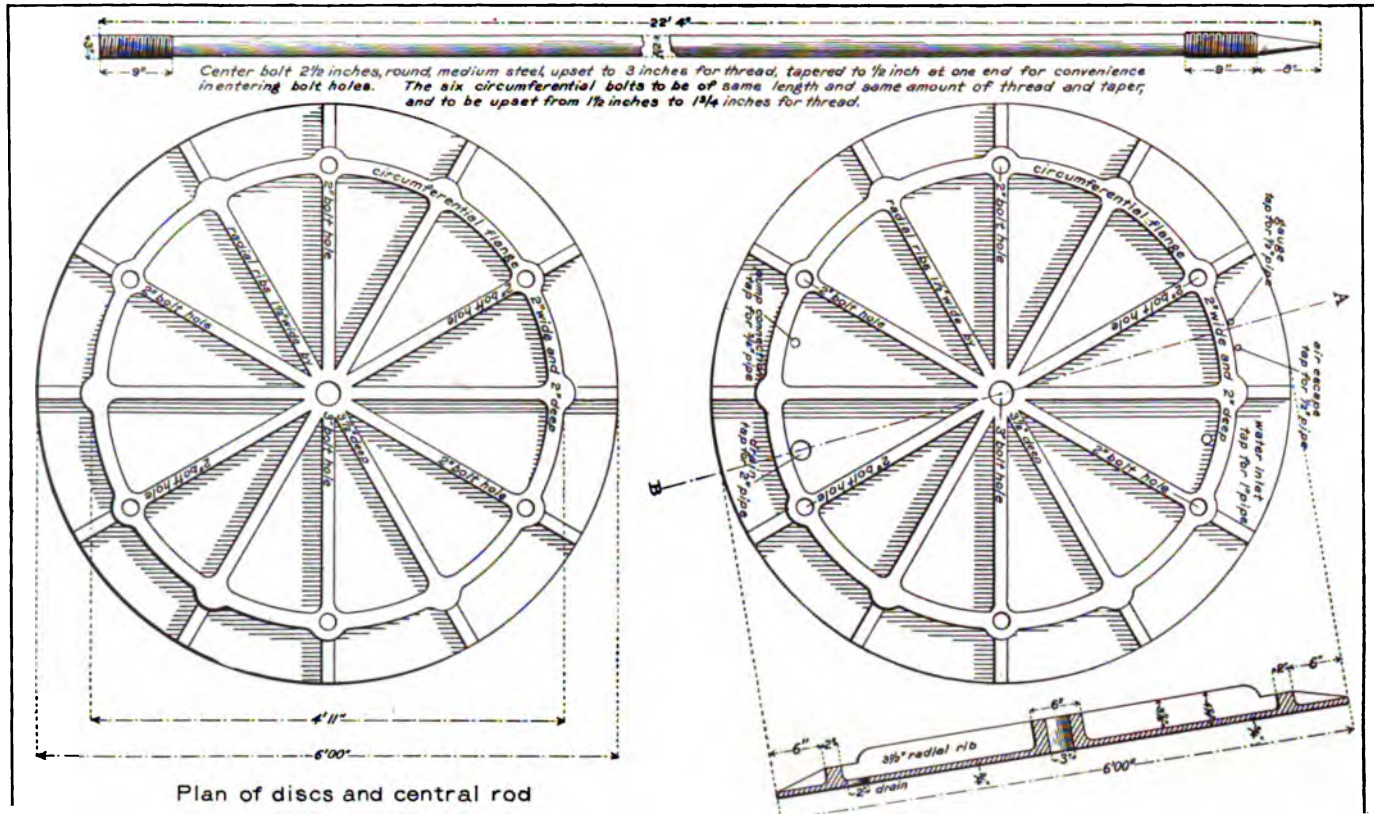
## TESTS.

The pipes lay in a position nearly east and west, the east ends being shown in the front of all photographs.

### PIPE NO. 1.

#### PLASTER LININGS.

On October 19, 1903, this pipe was covered on the inside with one-half inch of plaster. Four plasters were used, the section covered by each plaster being 5 feet in length.




Plan of discs and central rod

Plaster No. 1 was composed of 1 part cement to 1 part fine sand.

Plaster No. 2 was composed of 1 part cement and 1 part fine sand, mixed with alum and soap mixture—alum, 1 per cent by weight of cement and sand; soap, 1 per cent by weight of water.

Plaster No. 3 was composed of 1 part lime, 2 parts cement, and 6 parts sand.

Plaster No. 4 was composed of ¼ part lime, 1 part cement, and 3¾ parts fine sand.

The plasters were kept well wet for several days after completion, and the test of the pipe was not made until February 26, 1904.

PIPE No. 1, TEST 1.

The results of the first test of pipe No. 1 are shown in the following table:

*Test 1 of pipe No. 1.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Feb. 26 | 9.08 a. m. | 0 | Water turned into pipe. |
| | 12.58 p. m. | 0 | Pipe full. |
| | 12.60 p. m. | 15 | Leakage began. Especially strong along a longitudinal seam, hereinafter designated as a "tamping seam," caused by necessary delay in adjustment of form. |
| | Later. | 23 | Gage stationary; inflow counterbalanced by leakage. South side (most exposed to sun) is porous and leaks badly. No leakage from top section, which was tamped without form. |
| | 1.30 p. m. | 20 | |
| | 3.00 p. m. | ..... | Leakage on north side decreased fully 20 per cent. |
| | 3.20 p. m. | 24.5 | |
| | 4.45 p. m. | 25.5 | Decrease of 75 per cent in entire leakage. |
| | 5.00 p. m. | ..... | No leakage in top section. Pressure turned off for night. |
| Feb. 27 | 8.00 a. m. | 25 | Only 20 per cent of initial leakage persists. |
| | 2.00 p. m. | ..... | Top section shows little moisture only. North side, leakage almost ceased. South side, leakage decreasing; laitance appearing. |
| | | | Pressure continued all night. |
| Feb. 28 | 11.30 p. m. | 15 | Gasket blown out causing small leak. |
| | | | Pipe leaking on south side only. |
| | | | Pressure continued all night. |
| Feb. 29 | 8.00 a. m. | 14.5 | Not leaking appreciably except at gasket. Laitance oozed out, nearly stopping holes in pipe. |
| | 9.00 a. m. | ..... | Pipe emptied to repair gasket. |

Of the four plasters applied to the inside of the pipe, as described on page 19, it was found that No. 4 allowed the smallest amount of leakage, while Nos. 1, 2, and 3, in order, rank next in effectiveness.

When pipe No. 1 was being constructed the sections next to the top on both sides were made of dry mixture, by order of Mr. W. H. Sanders, as the watery cement was oozing from the boards at the bottom. It is remarkable that these two sections of 18 inches each show greater leakage and more gravel uncovered with mortar at the outside surface of pipe than the other sections. The other layers were put in very wet and the boards of the forms were coated with a layer of almost pure cement.

When the water was drained off and the disks were removed, an examination of the inside of the pipe revealed a hair crack the full length of the pipe on the south side, at the junction of the last section with the top section. This crack crossed all the mortars and was evidently due to a slight yielding of the concrete before the strain could be taken up by the steel armor.

This pipe was made with gravel of different sizes, with the idea that it might be less porous than a pipe with gravel of a more uniform size. It must be admitted, however, that the filling up of the interstices of the coarser material by the finer, which appears so plausible in theory, is most difficult to accomplish in practice.

The crack developed in the pipe shows that some lining or plaster of an elastic as well as of an impermeable nature must be found before these pipes can be placed under much pressure. A great many of the experiments have this end in view.

No arrangements had been made up to this time to measure the amount of the leakage from the pipes. It is evident that although a pipe might eventually dry up to such an extent under pressure as to reduce the leakage to an inappreciable amount, it might leak sufficiently before drying up to endanger its foundation, and cause the destruction of the pipe piecemeal. This would depend to some extent upon local conditions and the nature of the material on which the pipe rested. It will be seen from this experiment that the leakage is very much reduced by time, but it is doubtful whether this fact could often be used to advantage in practice, for the above-mentioned reasons.

The practically constant pressure of the city main was found to be much more advantageous for working on these pipes than the pressure developed by pumping. A quantity of laitance appeared on the outside surface of all pipes a few hours after they were put under pressure, and more or less matter composed of lime particles was con-

*A.* PIPE UNDER TEST.

*B.* METHOD OF RAISING END OF PIPE.

stantly exuding from them. Experience has shown that this material gradually fills up the pores and renders the pipe more impervious. A high pressure applied suddenly, as in pumping, would tend to force this matter rapidly through the pores and a great deal of it would be lost; whereas a slow, steady pressure would naturally permit a greater deposit. As a matter of fact few of the pipes or mortars were sufficiently impermeable to call for the aid of the pump in testing, as the city pressure varied between 37 and 42 pounds to the square inch, and this was as much as most of the pipes would stand without leaking so much as to endanger their foundations.

### Pipe No. 1, Test 2.

As stated above (p. 18), this pipe was coated inside with four plasters in 5-foot sections. It received an additional coating of two coats of P. & B. waterproof paint on the east half and two coats of Sylvester wash on the west half. On March 11, 1904, at 7.45 a. m., city water was turned on and gage immediately rose to 35 pounds. Leakage became free for the south side of the pipe, and was about twice as much as on the north side, while the portions covered by the P. & B. paint did not leak one-half as much as those covered by the Sylvester wash. This was very evident on top, which, in the section covered by P. & B. paint, showed barely a trace of moisture, but seven-eighths of the surface of the section covered by plaster No. 4 was moist. This was the plaster which showed the slowest percolation under test No. 1.

At 9 a. m. the gage registered 36 pounds and the leakage was 2¾ gallons per minute.

At 10 a. m. gage registered 37 pounds. Leakage about the same.

At 3 p. m. the pressure was reduced to 30 pounds and the leakage amounted to 2¼ gallons per minute.

## PIPE NO. 2.

### PLASTER LININGS.

This pipe was covered on the inside October 20, 1903, with a half-inch coat of two different plasters, the section covered by each plaster being 10 feet in length.

Plaster No. 1 at the east end was composed of 1 part cement and 3 parts sand, loose measurement.

Plaster No. 2 at the west end was composed of 1 part cement, one-half part lime, and 4½ parts sand, loose measurement.

PIPE No. 2, TEST 1.

The results of the first test of pipe No. 2 are as follows:

*Test 1 of pipe No. 2.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 1 | 9.00 a. m. | 0 | Water turned into pipe. |
| | 11.30 a. m. | 0 | Leakage from 2 pin holes, north side, one-third way up. |
| | 11.45 a. m. | 0 | Leakage from 3 more pin holes on south side, east section, along line of "tamping seam." |
| | 12.00 m. | 0 | Leakage from 5 more pin holes on south side at a "tamping seam;" 4 in east section, one in west section. |
| | 1.30 p. m. | ..... | Pipe full and pressure developed. |
| | 1.31 p. m. | 13 | Strong leakage commenced. |
| | 1.32 p. m. | 25 | Gage stationary, leakage counterbalances inflow. |
| | 2.00 p. m. | 25 | Leakage on south (sunny) side twice as great as on north. Practically no leakage on top section. |
| | 2.45 p. m. | 29 | Leakage decreased generally. |
| | 4.00 p. m. | 31 | Leakage still decreasing. |
| | 4.15 p. m. | 31 | |
| | 4.30 p. m. | 31.5 | Laitance and lime particles exuding freely. |
| | 5.00 p. m. | 31.75 | Leakage water shows lime. |
| | 8.05 p. m. | 35 | Entire top section sweating freely. Lime forming rapidly where leakage is greatest. |
| | 8.25 p. m. | 35 | Pressure continued all night. |
| Mar. 2 | 7.40 a. m. | ..... | Gasket on west end blown out. Pipe empty. |

The city pressure in the mains is greatest early in the morning, when the draft on the reservoir is least and the inflow has raised the water to its maximum level for that day. It is presumed that when this pressure came on the pipe the friction between the disk and the rubber was not great enough to hold the gasket in place and it blew out at the joint. As the pressure had remained for about 20 minutes at 35 pounds, it is presumed that the leakage had continued to decrease and the pressure to rise accordingly until this accident happened some time during the night. To prevent a recurrence of this trouble a welded steel ring of section one-half by 1 inch and large enough to fit around the gasket when under pressure was made for each end, and these were placed in position and the heads were screwed up a quarter of an inch tighter than before.

PIPE No. 2, TEST 2.

The results of the second test of pipe No. 2 are as follows:

*Test 2 of pipe No. 2.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 2 | 5.00 p. m. | 0 | Water turned into pipe. |
| | 8.10 p. m. | ..... | Pipe three-fourths full. Slight sweating on lower part of north side of east half and on south side of west half. Gaskets and rod washers tight. |
| | 9.40 p. m. | ..... | Pipe full and air vent closed. |
| | 9.43 p. m. | 30 | |
| | 9.45 p. m. | 32.5 | Leakage in streaks on both sides, most on south, none on top. |
| | 9.55 p. m. | 33.5 | Leakage worst on south side but less than in test 1, laitance and lime particles having closed some of the pores of the pipe. Water spurts to a distance of 4 feet from large pin hole near top on west end. |
| | 10.10 p. m. | 34 | Pressure shut off for night. |
| Mar. 3 | 7.40 a. m. | ..... | Pipe sweating and dripping at numerous points, mostly near east end. Water turned into pipe. |
| | 7.48 a. m. | ..... | Pipe full. See discussion below on amount of leakage. |
| | 7.49 a. m. | 25 | |
| | 8.00 a. m. | 32 | Leakage free on south side. At east end on south side there is a junction of the bottom and next section above. Water still spouts 4 feet from large pin hole. |
| | 8.55 a. m. | 32.75 | |
| | 10.00 a. m. | 34.5 | |
| | 11.00 a. m. | 35 | |
| | 11.15 a. m. | 35 | |
| | 11.15 a. m. to 4.45 p. m. | 35 to 36.5 | Leakage measured on weir shows about 3 gallons per minute, or five times as much as when pipe is full but under no pressure. |
| | 4.45 p. m. | 15 | Pressure reduced to 15 pounds for the night. |
| | 5.00 p. m. | 15 | Leakage measured on weir one-half gallon per minute, showing that pores had filled up somewhat during day, as it had leaked 0.6 per minute during previous night, when under no pressure. |
| Mar. 4 | 7.45 a. m. | 19 | Increase in pressure due to increase in city mains. Pipe sweating freely, 0.36 gallon per minute. Full city pressure turned on. |
| | 7.46 a. m. | 36 | |
| | 7.49 a. m. | 35 | |
| | 8.30 a. m. | 35 | Weir indicated leakage of 2.25 gallons per minute, a sensible decrease from day previous. |
| | 9.30 a. m. | 36.5 | One-inch tin weir substituted for 2-inch weir. Shows leakage of 2 gallons per minute. Greater part of leakage at one spot near bottom of pipe at east end. |
| | 10.15 a. m. | ..... | Pipe emptied and examined. |

It will be noted from the above table that on March 3 at 7.40 a. m. the water was turned into the pipe and in 8 minutes it was full, indicating that the pipe had leaked when not under pressure during the night a quantity equal to the run of the faucet for 8 minutes. Pipe No. 1 required 3 hours and 50 minutes to fill, and No. 2 required 4½ hours; the content of each pipe with heads screwed tight is about 395 cubic feet. Taking the mean time of filling the pipes as 250 minutes, the flow from the faucet would be 1.58 cubic feet per minute, and this multiplied by 8 equals 12.64 cubic feet, which represents the leakage during the night when no pressure was left on. This leakage, equivalent to 92½ gallons, occurred in 9½ hours of the night. This means a leakage from the pipe when not under pressure of 10 gallons an hour or 0.6 of a gallon per minute.

Provision was then made for measuring the leakage from the pipe when under pressure by making drains beneath it for collecting all the leakage water and leading it to a small tin weir 2 inches long.

The sand-cement plaster lining contained a perfect network of hair cracks, while the lime-cement plaster showed hardly any. The greatest leakage appeared to be in the east section of the pipe, which had been plastered with the sand-cement mixture.

Both sides of the pipe were thickly covered with laitance and lime deposits, but very little of either of these appeared on the top of the pipe.

PIPE NO. 2, TEST 3.

This pipe was originally treated with two kinds of cement mortar, and when tested the first time showed a leakage of 3 gallons per minute under a pressure of 37 pounds per square inch. It was then washed on the inside of the east half with two coats of pure cement wash, and on the west half with two coats of Sylvester wash.

*Test 3 of pipe No. 2.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 17 | 7.30 a. m. | 32 | No leakage below this pressure. |
| | | 35 | Leakage 1 gallon per minute. |
| | | | Top section of the pipe shows moisture only in spots over about one-third of its area. |
| | 9.00 a. m. | 36½ | Leakage 1 gallon per minute. |
| | 10.00 a. m. | 37 | Do. |
| | 1.00 p. m. | 39 | Do. |
| | 3.00 p. m. | 38 | Do. |
| | | | Considerable laitance formed on upper half of pipe. Leakage more of a general sweat and less flowing streams. |

*Test 3 of pipe No. 2*—Continued.

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 17 | 5.00 p. m. | 38 | Leakage about 1 gallon per minute. Full city pressure left on all night. |
| Mar. 18 | 8.00 a. m. | 35 | Leakage 2½ gallons per minute; caused probably by opening of new pin holes or seams as result of extra-heavy pressure on city mains developed during the night. |
| | 8.30 a. m. | 0 | Pipe allowed to remain full all day and during night |
| Mar. 19 | 8.00 a. m. | 22 | Full city pressure turned on. No leakage, except at one spot in bottom; apparently a serious imperfection in pipe. |
| | 8.15 a. m. | 24 | Seepage on surface of pipe. |
| | 9.00 a. m. | 35 | Sweat is more general, but not as much as on Mar. 17. |

PIPE NO. 2, TEST 4.

Pipe No. 2 received a coat of Richards plaster, which was placed over the plaster already on from test 2, and a half sack of clay was deposited in the pipe before the heads were attached. On April 28, 1904, this pipe was filled at 2 p. m. Pressure, however, was not applied till 2.30 p. m., so that Mr. Richards might be present at the test. There was absolutely no moisture visible on the outside of the pipe up to this time. This was not the case in previous tests. When the pressure was applied, the gage rose steadily until it reached 32 pounds and fluctuated between 32 and 34 pounds for half an hour before any leak was seen except near the bottom on the west end, where there was supposed to be a flaw in the pipe. In an hour there was a strong sweat at several places on the outside of the pipe, but not sufficient to allow any water to flow away. The weir showed a leakage of nearly 2 gallons per minute, nearly all of which came from the flaw. At 5 p. m. there was a trifle more sweat on the pipe, but the ground under and around the pipe remained dry, except at the west end, where the flaw was located. The pressure was now reduced and the pipe was left under a low pressure all night.

In the morning (April 29) the pipe was very sweaty under a pressure of 12 pounds, although there were several dry spots. The ground was somewhat moist in places, but was not soaked. The full pressure was now turned on, and the gage rose to 35 pounds. There was no visible leakage, the surface of the pipe drying off rapidly under the influence of the sun's rays. The water in the pipe was stirred up at intervals to keep the clay moving. The pipe remained under this pressure all day without any apparent change. The water which escaped through the flaw was colored with clay.

The pump was applied in the afternoon and the pressure was raised to 40 pounds. The leakage through the flaw was so great, however, that it was determined to remove the heads and repair the flaw. This was done, and on May 2, 1904, the pipe was overhauled and a distinct crack was found in the plaster over the flaw in the pipe. The plaster was chipped off for about 2 feet square, and the imperfect part of the pipe itself was chiseled out to a depth of 2 inches. This was filled with good cement mortar and allowed to set thoroughly. In cutting into the crack or flaw it was found partly filled with clay.

On May 5 a coat of Richards plaster was placed on that part of the pipe that had been repaired, and on May 10 the pipe was filled at noon. As soon as the pressure was turned on the gage rose slowly to 39 pounds, and fluctuated between 38 and 40 pounds till 12.30 p. m., when moist spots began to show on the outside of the pipe, mostly on the south side.

At 1 p. m., the pressure remaining the same, the total amount of moist surface on the south side did not exceed 1 square yard, while the amount on the north side did not exceed 1½ square feet.

At 1.30 p. m. the sweating had spread a little more, the pressure remaining the same. A little leakage around the gasket at the west end was probably caused by the plaster near the flaw not being thoroughly set. This leakage through the gasket amounted to a little less than one-tenth gallon per minute. The pump was now attached and the pressure was raised to 53 pounds, when the pipe commenced to sweat considerably. The pressure was kept up to this point for fifteen minutes, the sweating increased somewhat, and water began dripping in places along the south side.

At 2 p. m. the pressure was raised to 63 pounds and held there by pumping for two minutes. This developed a very strong sweat and a small leak near the top on the north side. The dripping increased to such an extent as to cause water to gather in the little drains at the sides of the pipe. The pressure was now lowered to 55 pounds and held there till 2.45 p. m., when the leakage amounted to half a gallon per minute, fully one-fifth of which came through the gasket. The pressure was maintained at from 53 to 56 pounds until 3.45 p. m., and the clay was kept in motion all the time, the weir showing an increase under this constant pressure.

At 4 p. m. the pressure was allowed to fall to that of the city mains, and the gage registered 37 pounds.

At 4.30 p. m. the weir showed a leakage of one-tenth gallon only, which came entirely from one leak at gasket, the drip from the sweaty sides of the pipe not being sufficient to make the water flow to the weir. The pipe was left under pressure all night.

On May 11, at 8 a. m. the gage registered 38 pounds, the weir did

not show any flow, and there was scarcely any drip from the sides of the pipe. The pipe was allowed to stand under city pressure and the clay stirred up occasionally until 3 p. m., when the pump was applied and the pressure raised to 55 pounds. At this pressure the weir showed a leakage of four-tenths of a gallon per minute. The pressure was then raised to 62 pounds and held there for a few minutes, and the leakage shown by the weir was three-fourths of a gallon per minute. When the pressure was reduced to 55 pounds the leakage fell to four-tenths of a gallon per minute.

The pipe remained under pressure all night, and at 8 a. m. on May 12 the gage read 39 pounds and there was no drip from the pipe. The surface on the outside of the pipe, however, was sweaty, but this moisture disappeared to a great extent under the influence of the sun. The pipe remained under city pressure all day (37–39 pounds) and the clay was kept stirred up occasionally, but there was no apparent change in the condition of the pipe, so this experiment was concluded, and the heads were moved to No. 3. This was a very satisfactory test.

When this pipe was thoroughly washed inside to remove the clay, it was found that the plaster was still soft. This might account for the high pressure which this pipe stood, as a harder mortar might have cracked and caused greater leakage. A plaster which would remain soft and plastic for a long time might possibly afford a solution of the problem.

It will be observed that in these tests the amount of leakage varies considerably with the same pressure on different pipes. It was thought at first that the pressure and leakage should be proportional, but a little consideration will show that this could not be so.

It requires a greater pressure to force a given quantity of water through twelve small holes than it does to force the same quantity of water through one hole as large as all the small ones together, in the same time. If, therefore, the quantity of water which leaks through a pipe with only one opening is the same as that which passes through numerous small holes in another pipe in the same time, it is evident that the pressure on the pipe with small holes must be greater than that on the pipe with one large hole.

We may conclude then, that the pressure on a sweaty pipe will be greater than on a pipe with a few well-defined leaks, where the leakage is the same in both, in the same time, and that, with the same pressure, the leakage may vary with the number and character of the openings through which it takes place. This shows the great importance of careful workmanship on pipes of this kind. Unfortunately this class of work is most frequently done with unskilled labor, so that the practical difficulties in the way of producing a waterproof pipe, for a reasonable price, are thereby much increased.

## PIPE NO. 3.

### PIPE NO. 3, TEST 1.

This pipe, as may be seen from its composition (p. 14), was made with the idea of testing a pipe constructed of waterproof material and no coat of plaster was placed upon the inside.

*Test 1 of Pipe No. 3.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 7 | 4.00 p.m. | 0 | Water turned into pipe. |
| | 5.00 p.m. | 0 | Leakage commenced on south construction side of pipe; in general, much less leakage than in pipes Nos. 1, 2, and 4, as filling proceeds. |
| | 7.45 p.m. | 0 | Leakages from pinholes in tamping seams at bottom are more numerous than elsewhere. |
| | 9.15 p.m. | 4 | Pipe full and pressure turned on. Many pin holes develop. Leakage exceeds 9 gallons per minute. Pipe most impervious of any yet tested. Pressure turned down for night. |
| Mar. 8 | 9.30 a.m. | 4 | Leakage 9 gallons per minute. |
| | 10.00 a.m. | 5 | Leakage about the same. |
| | 10.30 a.m. | 6½ | Leakage 8 gallons per minute. |
| | 10.45 a.m. | 7 | Do. |
| | 11.00 a.m. | 8 | Do. |
| | 4.00 p.m. | 11½ | Leakage 6 gallons per minute. |

In the first test it was left in its rough state inside, just as it came from the forms, without any mortar, and the highest pressure that could be obtained on it was 12 pounds to the square inch, with a leakage of 5 gallons per minute. As the leakage was already sufficient to show that it would be unwise to build a pipe under such conditions in practice, it was determined to conclude this experiment, and the water was turned off and the pipe allowed to drain.

It was decided to give this pipe a coating of the different kinds of plaster and make another test on it, which is described below. It is very evident from the experiments that although the leakage decreases rapidly with time, some impermeable mixture in the shape of plaster must be applied to the inside of these pipes to prevent the immense leakage which would otherwise take place when the water is turned into the pipe. Such a plaster would allow a more gradual penetration of the material of the pipe by the water, and probably afford better conditions for filling the pores of the concrete with the compounds of lime which tend to close them, and render the concrete impervious.

PIPE NO. 3, TEST 2.

The original composition of the pipe was 1 part cement, 2 parts sand, and 3.2 parts gravel (half-inch mesh), mixed with water impregnated with soap and alum.

The pipe now was coated inside on the east half with a mortar half an inch thick, composed of 1 part of lime paste, 1 part of iron filings, 2 parts of cement, and 6 parts of sand, all mixed with water having iron filings and sal ammoniac in the proportion of 70 pounds of iron filings and 12 ounces of sal ammoniac to 42 gallons of water. This mortar was first tried without lime, but it was found very difficult to make it adhere to the pipe. The lime was added to overcome the difficulty, and was quite successful for the purpose. The west half of this pipe was coated with half an inch of mortar, composed of 1 part of fine clay and 1 part of cement. This mortar checked badly in setting, but it was allowed to dry under the same conditions as the other mortar, the checks being permitted to remain as they developed, in order to determine how it would act under pressure. The iron mortar was finished on March 9, the clay mortar on March 10, and the pressure was turned on the pipe at 4 p. m. March 14. The pressure ran up rapidly to 20 pounds per square inch without any leakage. Some small seams and pin holes then commenced to leak, and kept increasing until the pressure was up to 35 pounds, when the leakage amounted to 2½ gallons per minute. Three-fourths of this leakage was in the clay end of the pipe, and the iron mortar was evidently by far the more impermeable. From 4 to 5 p. m. there was a very evident filling up of the leaky spots, all the pin-hole jets decreasing until they were tiny leaks. The pressure was left on all night, and on the morning of March 15, at 8.30, the gage read 38 pounds, and the leakage was a little less than 1 gallon per minute.

With a pressure of 35 pounds the leakage through the iron mortar is not over one-tenth of that through the clay, and is so small as to be of no consequence in practice. The result of this experiment shows that with a pipe of Sylvester wash composition, and a mortar of iron filings, sal ammoniac, cement, lime, and sand, a head of 80 feet would be possible. Just how the sal ammoniac would act on the steel armor embedded in concrete it is impossible to state, and the condition of the armor when the pipe was broken is noted on p. 58.

One peculiar circumstance connected with this pipe was that although the pressure in the morning was 38 pounds with a leakage of less than a gallon per minute, when the pressure was down to 35 pounds, owing, it is supposed, to the variations in the quantity of water drawn from the city pipes, water commenced to spurt in high jets from the pin holes, which had shown very little leakage at 38 pounds. These jets were all in the clay portion of the pipe. A possible explanation of this peculiar action is that the pin holes had been stopped up by small,

loose particles of clay on the inside surface of the mortar. As soon as the pressure was relieved by a sudden draft on the city water pipes these particles may have been so far removed to one side of the pin hole as to allow the water to spout again. The pump was turned on to this pipe at 9 a. m., and the pressure forced up to 42 pounds. This started a few small jets through the iron mortar and increased those already found in the clay mortar to such an extent as would prevent the use of that part of the pipe under that pressure in practice. When the heads were removed it was found that the mortars had cracked for the full length of the pipe in four different places at tamping seams, and all of the pin-hole leaks through the iron mortar were traced to these seams.

It was noticeable in this test that considerably more laitance appeared on the surface of the pipe at the east end than on that of the west end, although the leakage was very much less on the former section.

Thirty-eight pounds seems to be about the limit of pressure for this pipe and mortar. This is equivalent to a head of 87 feet, but considering the many imperfections of work in actual practice, it would not be safe to count on over 70 feet of head on such a pipe, and then only after the most rigid inspection and supervision of the construction of the pipe.

It is evident from this experiment that as soon as the pressure is sufficient to stretch the steel beyond the tensile strength of the concrete the yielding of the concrete will allow the weakest seam to open.

When pumping, the pressure tending to burst the pipe was, for 1 inch in length of pipe,

$$42 \times 30 \text{ (radius in inches)} = 1{,}260 \text{ pounds,}$$

and the area of section of concrete resisting this pressure was 6 square inches, so that the actual strain on the concrete alone amounted to $\frac{1260}{6} = 210$ pounds per square inch. The steel rods are three-fourths inch in diameter and are set $3\frac{3}{8}$ inches from center to center, so that if the pressure is taken up by the steel alone it would amount to

$$\frac{1260 \times 3\frac{3}{8}}{0.44} = 9{,}664 \text{ pounds per square inch,}$$

and although this is below the elastic limit of the steel this strain would cause the steel to stretch enough to crack the concrete, which, of course, would yield first at the weakest place, probably a seam.

Practically, it is very difficult, if not impossible, to make concrete pipes of large diameter without seams, either longitudinal or transverse, and to overcome this defect it would be necessary to have an elastic as well as an impermeable quality in the plaster. Efforts will be made in future tests to find such a plaster for lining.

PIPE NO. 3, TEST 3.

In the second test of this pipe, described above, two different kinds of mortar were used—iron mortar on the east half and clay mortar on west half. As the clay mortar did not give satisfactory results it was chiseled off and in its place was substituted a plaster composed of 1 part of Ideal cement, 1 part screened sand, and one-fourth part lime putty, all moistened with iron and sal ammoniac water. The east half was allowed to remain as it was in test No. 2. The entire inside of pipe was coated with a wash of cement mixed with "iron" water.

*Test 3 of pipe No. 3.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 23 | 2.55 p. m. | 25 | Pressure turned on. Number of pin holes north side near top spouting. |
| | | 30 | Few small leaks on south side near top. |
| | 3.30 p. m. | 35 | Leakage strong along two of the cracks which were visible on inside of the pipe after second test. |
| | 4.00 p. m. | 39.25 | Leakage 1.75 gallons per minute. Leakage on south side diminished. No pin holes spouting. North side, 9 or 10 pin holes spouting. Ninety per cent of all leakage occurs here. |
| | 4.30 p. m. | 39.25 | Same leakage as above. |
| | 5.00 p. m. | 20 | Pressure reduced for the night to allow cracks to close up. Leakage 0.75 gallon per minute with strong sweat at cracks and no pin holes. |
| | 8.15 p. m. | 30 | Leakage 0.75 gallon per minute. Strong sweat. No pin holes. |
| Mar. 24 | 7.30 a. m. | 36 | Leakage 0.25 gallon per minute. |
| | 7.30 a. m. | 38 | Full city pressure. No perceptible change in appearance of pipe. |
| | 8.00 a. m. | 39.5 | Leakage 0.25 gallon per minute. |
| | 9.00 a. m. | 40 | A few pin holes commenced to spout. Pressure then turned down to 32 pounds, and spouting ceased. |
| | | | This pressure continued to ascertain if leaking seam will close or cease to leak at higher pressure. |
| | 12.00 m. | 32 | Pipe drying fast. Weir shows leakage less than 0.1 gallon per minute. |
| | 2.00 p. m. | 32 | Pipe much dryer. |
| | 4.30 p. m. | 35 | Leakage so small as to be barely recorded. Pipe dry over half this surface. |
| Mar. 25 | 7.30 a. m. | 34 | Only sweat in parts of crack. Weir shows no perceptible leakage. Full city pressure turned on. |
| | 7.45 a. m. | 40 | No strong leaks until 8.15. |
| | 8.15 a. m. | 40 | Leakage 0.3 gallon per minute. Pump started and pressure raised to 45 pounds. All pin holes spout freely. |
| | | 48.5 | Cracks leaked so much that pump can not overtake leakage. |

When the heads were removed from this pipe the two old cracks from test 5 were seen plainly developed in the plaster, although one did not run through the full length of the pipe. There were also three small new cracks visible. This was certainly the most satisfactory of all the tests so far. It must be borne in mind that a pipe in actual practice would not be subject to much fluctuation in pressure, and as long as the pipe did not leak materially under the pressure due to the maximum level of water in the canal, it would probably get more impermeable with age. The ends of the pipe being always open it could not be subjected to very severe water hammer if proper provision was made for removing air.

### Pipe No. 3, Test 4.

When this test was made the pipe was in the same state as after the third test, except that the plaster was repaired. Before the heads were put on this pipe there was placed inside of it 100 pounds of clay and 2 pounds of wood ashes, the object of this test being to determine the efficiency of clay and ashes as a means of stopping leakage in a concrete pipe.

On April 19, 1904, at 3.45 p. m., this pipe was filled and the pressure rose to 25 pounds before any noticeable leak occurred. When the pressure reached 30 pounds leakage became greater, and water spouted very freely along the seams that had been chiseled out and filled with mortar on the inside. The clay and ashes were kept well stirred up inside and the water which came through the leaky places was very muddy. The pressure was gradually increased to 32 pounds; the leakage was 4½ gallons per minute. This pressure was kept on during the rest of the day, the clay being stirred constantly. At 5 p. m. the pressure was reduced for the night. On April 20, 1904, at 8 a. m., full pressure was again turned on and clay stirred up. The pressure rose to 34 pounds and the leakage amounted to 3¾ gallons per minute. By noon the pressure had increased to 35 pounds, but the clay seemed to blow through the cracks and the pipe was leaking so much that it was decided to discontinue the experiment.

### Pipe No. 3, Test 5.

The pipe was thoroughly washed inside to remove all the clay which remained after test 4. This left the pipe with one-half inch of two different kinds of plaster on the inside, as described in tests 3 and 4.

On April 26 an additional plaster of 1 part of cement to 1½ parts of sand was applied and troweled down to a smooth surface. This plaster was kept well wet till seasoned, and on May 14 the pipe was filled, a sack of clay having first been deposited inside.

*Test 5 of Pipe No. 3.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| May 14 | 10.30 a. m. | 32 | Two large pin holes near top on east end of north side; 1 small pin hole at west end. |
| | 11.00 a. m. | ..... | Strong sweat spots on north side. Small pin holes stopped spouting. |
| | 12.00 m. | 37 | General sweat on pipe. Leakage 0.75 gallon per minute. Clay stirred constantly, and pressure allowed to remain all the afternoon, fluctuating between 35 and 40 pounds. |
| | 5.00 p. m. | ..... | Weir indicates leakage of a little more than one-half gallon per minute. |
| May 16 | 8.00 a. m. | 38 | General sweat; 2 large pin holes, leaking freely. Total leakage, one-half gallon per minute. |
| | 5.00 p. m. | 36 | Leakage about same as in the morning. |
| May 17 | 8.00 a. m. | 39 | Leakage 0.4 gallon per minute. Considerable laitance has formed on outside of the pipe. As finger is run along full length of pipe sweat seems to break and does not show any flow except on north side, where several leaks are found. At place of leakage thick coat of iron oxide deposited on outside of pipe. Clay constantly stirred during forenoon. |
| | 12.00 m. | 39 | Leakage 0.35 gallon per minute. |
| | 2.30 p. m. | 56 | Pump attached. Pressure maintained for 25 minutes. Leakage of 1 gallon per minute. Leakage along upper seam on north side. Strong sweat on south side |
| | 2.55 p. m. | 62 | Pressure raised by fast pumping and held for 12 minutes. Leakage 2 gallons per minute. Ten per cent from bolt holes and gaskets. |
| | 3.00 p. m. | ..... | Pressure allowed to fall to that in city mains and maintained there for remainder of day. |
| | 3.30 p. m. | 36 | Leakage 0.75 gallon per minute. This would indicate that the pores of the pipe had been opened by great pressure. |
| | 5.15 p. m. | 38 | Slight reduction in leakage. Pipe is left under city pressure all night. |
| May 18 | 8.00 a. m. | 39 | Leakage 0.5 gallon per minute. Pores apparently closing up. Pressure kept on all day; clay agitated. |
| | 5.00 p. m. | 38 | Slightly reduced leakage. Pressure left on all night. |
| May 19 | 8.00 a. m. | 37 | Leakage 0.35 gallon per minute. Pipe under city pressure all day. |
| | 5.00 p. m. | 38 | Leakage 0.35 gallon per minute. Pipe under pressure all night. |
| May 20 | ..... | 37 | Leakage 0.35 gallon per minute. Considerable laitance and lime on the surface. No leakage, except at pin holes, where oxide of iron is getting harder. Pipe under pressure all night and all next day. |

*Test 5 of Pipe No. 3*—Continued.

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| May 20 | 5.00 p. m. | ..... | Pipe quite dry. Leakage 0.3 gallon per minute. Pipe left under pressure until May 23, when pressure was reduced to zero. |
| May 25 | ..... | 38 | Leakage 0.25 gallon per minute. Pipe left under pressure for night. |
| May 26 | ..... | 38 | Leakage 0.1 gallon per minute. Pressure continued. |
| May 27 | ..... | 38–40 | Same leakage; pressure released at noon. |
| | 5.00 p. m. | ..... | Pressure again applied and continued all night. |
| May 28 | ..... | 39 | Pipe quite dry. Leakage less than 0.1 gallon per minute. Pressure continued. |
| May 29 | ..... | 39 | Conditions same as day previous. Pressure now turned off. Pipe allowed to remain full of water until June 2. |
| June 2 | ..... | 60 | Pressure raised by pumping. Increased for a short time to 65 pounds, when new pin holes blew out on south side. Pressure allowed to fall to 38 pounds and allowed to remain there until June 9. |

This pipe was left under city pressure from 5 p. m., May 14, to 8 a. m., May 16. Many engineers and practical pipe makers assert that time is an important element in closing the pores of a cement pipe. This was considered an excellent opportunity for this test, as the workmen were employed in the yard making another pipe of the same diameter and thickness, but in sections of 5 feet each.

June 9, 1904, when the leakage had been reduced so that it could no longer be measured through a weir 1 inch wide, the only leaks visible on the surface were from the two pin holes on top, and the leaks from them had been very much reduced in the last few days. This pipe had now been practically under city pressure for about three weeks, and the leakage had decreased from three-fourths gallon per minute to less than one-tenth gallon per minute.

This reduction of leakage might be due to the filling up of the pores of the pipe in this case with clay, lime deposits, laitance, or oxide of iron, or partly with one or more of these substances.

The fact that oxide of iron formed rapidly on outside of the pipe only at the pin holes does not necessarily prove that the sal ammoniac might permeate the concrete and attack the steel rods, but naturally leads to grave suspicion that it does so. An examination of the steel rods where the pipes are broken up will show what has happened.

Just what influence the clay may have had in this case it is difficult to say, but another experiment will show what clay can do on an unplastered concrete pipe.

## PIPE NO. 4.

### PIPE NO. 4, TEST 1.

Pipe No. 4 was constructed September 12, 1903. No plastering was done on this pipe. During the time the experiments were being made on pipes Nos. 1 and 2, from February 26 to March 4, 1904, this pipe was coated inside on its east half with two coats of P. & B. waterproof paint No. 1, and its west half with three coats of soap and alum mixture, commonly called "Sylvester wash." This was applied precisely as recommended in Trautwine's Pocket Book, p. 672. It was assumed from the results of experiments on pipes Nos. 1 and 2 that it would be useless to attempt a test of a pipe without some waterproof plaster or wash on the inside. The Sylvester wash being so much used for waterproofing was thought to be a good wash with which to make the first test, and as an elastic coating of some kind was deemed important the P. & B. paint was selected.

*Test 1 of pipe No. 4.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 4 | 4.30 p. m. | 0 | Water turned into pipe. |
| | 5.00 p. m. | 0 | 2 small sweat spots on P. & B. section; strong drip on Sylvester wash section. |
| | 8.40 p. m. | 0 | Pipe seven-eighths full. Only slight seepage in lower half. |
| | 9.25 p. m. | 0 | Pipe full. Leaks develop freely in both sections. Gage would not record; therefore removed for repairs, and light pressure left on pipe all night. |
| Mar. 5 | 8.00 a. m. | 7 | Leakage 9 gallons per minute. |
| | 10.00 a. m. | 8½ | Leakage decreasing. |
| | 3.30 p. m. | 10½ | Leakage decreasing, but still sufficiently bad to render pipe unsafe in practice. Water shut off and pipe allowed to soak. |
| Mar. 7 | 8.00 a. m. | 0 | Water leaked out amounting to 26 gallons per hour. |

The appearance of the pipe outside and the location and quantity of the leakage indicate that the Sylvester wash makes a better lining than the waterproof paint. On the Sylvester wash section of the pipe there were several streaks of absolutely dry concrete, whereas the P. & B. section showed moisture on all the surface except the top, which, as the pipe had been reversed in position, was the bottom during construction.

The reason for so much leakage through a so-called "waterproof" paint was explained by an examination of the inside of the pipe. It

was found that as the inside surface was rough, many indentations had simply been bridged over by the paint, and when pressure was applied these spots had yielded and allowed water to pass through.

The result of this test with the Sylvester wash is disappointing, and it is easy to conjecture what the leakage from the pipe would have been without the wash. The difference in leakage between the plastered pipes Nos. 1 and 2, and No. 3, which was washed, would seem to favor the application of a good plaster to the inside of all concrete pipes subjected to the pressure of water.

It was remarked in the tests of the pipes Nos. 1 and 2 that the leakage on the south side of each of these was very much greater than that on the north side. These pipes, although rolled over from where they were made, stood in the same relative position as to top and bottom as that in which they were made. It was at first thought that the action of the sun on the south side of these pipes for the five months during which they had remained in the yard had affected that side injuriously, but when pipe No. 4 was being tested it was observed that the greatest leakage occurred on the north side. On examination of this pipe it was found that it stood in the reverse position from that in which it was made—that the bottom of the pipe now stood uppermost.

It is evident, then, that it was not the fact that the pipes had stood so long under the rays of the sun in the yard after being made that had affected the south side injuriously, because in pipe No. 4 the north side instead of the south side seemed to have been affected. As all the pipes were made on the same spot it is probable that it was the greater evaporation on the sunny side when the pipes were being made, especially at the tamping seam, that had affected them in this way, and all the experiments tended to corroborate this view of the matter. It would seem advisable, therefore, in making concrete pipes to hold water to insist upon their being made in the shade. As in the other pipes, the bottom of this pipe does not leak nearly as much as the sides, the moisture not being sufficient to cause any flow.

### Pipe No. 4, Test 2.

As stated above, this pipe was coated on the inside with two coats of P. & B. waterproof paint on east half and with two coats of Sylvester wash on the west half. The first test was completed on March 7, 1904, and on March 28 this pipe was coated on the west end, over the Sylvester wash, with a plaster made of 1 part boiled linseed oil, 2 parts coal tar, 1 part sand, and 1¼ part cement; and on the east end over the P. & B., with a wash composed of 1 part of boiled linseed oil and 2 parts coal tar, enough to make a good, thick paint. This was laid on with a brush.

*Test 2 of pipe No. 4.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Apr. 1 | 8.00 a. m. | 0 | Water turned into pipe. |
| | 12.20 p. m. | ..... | Pipe full; some sweat during filling process. |
| | | 10 | Pipe commenced to leak. |
| | | 16 | Leaked freely; less under plaster than under wash. |
| | 12.40 p. m. | 18 | Leakage 6 gallons a minute. |
| | 1.30 p. m. | 19 | Do. |
| | 2.30 p. m. | 21 | Slight decrease of leakage; pipe sweating over whole surface; pressure now cut to 4 pounds. |
| | 4.30 p. m. | 5 | Pressure increased; leakage 2.75 gallons per minute. |

It has been suggested by a great many engineers and practical men in the pipe business that fine clay or ashes, or both, deposited in the water passing through the pipe would eventually seal up all the leaks and make the pipe practically tight.

It was determined to test this theory, and accordingly a small stuffing box was placed on one of the cast-iron heads, and an agitator in the form of a small rake with a handle of half-inch round steel, working in the stuffing box, was added to the equipment, so that the clay was kept stirred up when the pipe was under pressure.

It was determined to make a close examination of all the pipes tested up to this time, with a view to putting them in shape for testing some more theories of making steel-concrete pipe impermeable in actual practice. During the examination it was found that in order to make the pipes serviceable for further tests it would be necessary to chisel out the longitudinal cracks which had been developed in pipes Nos. 3 to 5, inclusive, and fill up these cracks with a strong mortar. The cracks were accordingly chiseled out about 1 inch deep. In doing this three important facts were disclosed.

(1) Pipe No. 5 was not a hard concrete. It seemed to be of a crumbly nature, and it would have been easy to cut a hole through it.

(2) Some of the longitudinal cracks in pipes Nos. 3 to 5, inclusive, were found to be in radial planes through the longitudinal rods, but only at the rods which are placed on the sides of the pipe, in sections A, A, as shown in fig. 1, p. 16.

It is possible that in tamping, the longitudinal rods in sections A, A may have sprung a little and exerted a tensile strain at these points in the material of the pipe, rendering them the weakest places when the additional pressure of the water was turned on.

(3) The concrete in No. 3 was exceedingly hard, and the plaster had become loose in the bottom part of the pipe, so that it was an easy

matter to remove a strip 2 feet wide for the full length of the pipe. This strip was replaced with fresh mortar of the kind used on this pipe before.

## PIPE NO. 5.

### PIPE NO. 5, TEST 1.

The west third of the pipe was covered on the inside with one coat of a wash made by Mr. C. E. Richards, of Los Angeles, who claims to have a waterproof wash and plaster for concrete or brick walls. The middle third had one coat of plaster and one coat of wash, and the east third of the pipe had two coats of plaster. This pipe was made September 22, 1903, and treated inside by Mr. Richards March 9 and 10, 1904. The wash was applied on March 9 and the mortar on March 10. The plaster has a very smooth and oily appearance. The process is not patented, but is a trade secret.

*Test 1 of pipe No. 5.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 12 | 10.50 p. m. | 0 | Water turned into pipe. |
| | 12.30 p. m. | 9 | Slight leakage in west section, which was covered with wash only; remainder of pipe dry. |
| | 3.30 p. m. | 5 | Pipe full. Several pin holes on south side of west third commenced spouting. |
| | | 9 | Few pin holes appear in east section, where lining was plastered only. |
| | | 10 | Few more pin holes in center section where lining is both plaster and wash. |
| | | 24 | Leakage rapid. |
| | 4.10 p. m. | 25½ | Leakage 6 gallons per minute. |
| | 4.30 p. m. | 28 | Leakage 5 gallons per minute. |
| | 4.40 p. m. | 29 | Leakage 4.5 gallons per minute. |
| | | | Pressure turned off; pipe allowed to remain filled with water. |
| Mar. 14 | 7.45 a. m. | 0 | Pipe quite dry on outside. |
| | | | Leakage without pressure inconsiderable. |
| | | 20 | No leakage until this pressure is reached, when seams and pin holes spurt as on Mar. 12. |

As this pipe had leaked so much in first half hour under pressure, the experiment was concluded.

### PIPE NO. 5, TEST 2.

In the first test of this pipe it was coated on inside with Richards wash and plaster as follows: West third, one coat of wash. Middle third, one coat of plaster and one coat of wash. East third, two coats of plaster.

On March 22, 1904, this pipe received on the east and middle thirds an additional coat of plaster. This plaster was composed of 1 part cement, 1 part screened sand, and one-fourth part lime putty moistened with iron water. When dry it was covered with a light wash of iron and cement. On March 23 the west third received a coat of Richards plaster.

*Test 2 of pipe No. 5.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 29 | 4.15 p. m. | 18 | Leaks begin to show on outside. |
| | | 20 | Leaks quite free. Numerous pin holes near the top in "iron plaster" region of section, while Richards plaster section remains dry. |
| | | 25 | Richards plaster section begins to show leakage, though not as much as remainder of pipe. Total leakage 4½ gallons per minute. |
| | 4.40 p. m. | 28 | Leakage same. Pressure reduced to 12 pounds for night to prevent too much leakage. |
| Mar. 30 | 8.00 a. m. | 23 | Leakage 1 gallon per minute. Thirty per cent of this leakage from cracks in the plasters on the end of the pipe where pressure under gasket has affected them. |
| | 8.00 a. m. | 30 | No perceptible increase in leakage. |
| | | 34 | Strong leakage at 2 spots on south side at junction of 2 plasters. No pin holes. |
| | 9.00 a. m. | 36 | Leakage 3 gallons per minute. Ditches running to weir and submerged surface of weir sustained heavy deposit of laitance. |
| | 10.00 a. m. | 36 | Leakage 3 gallons a minute. |
| | 11.00 a. m. | 36½ | Do. |
| | 12.00 m. | 37 | Do. |
| | 2.00 p. m. | 37½ | Leakage 2.75 gallons per minute. |
| | 3.00 p. m. | 37 | Do. |
| | 5.00 p. m. | 37 | Do. |
| | | | Pressure reduced to 8 pounds for the night. |
| Mar. 31 | 8.00 a. m. | 14 | Leakage ¾ gallon per minute. General sweat on the pipe. Full city pressure turned on and gage raised at once to 35 pounds. |
| | 8.30 a. m. | 36 | Leakage 2½ gallons per minute. |
| | 9.00 a. m. | 36 | Same leakage. Force pump applied. |

The pressure could not be raised above 39 pounds with the pump, although the pin holes did not spout. As the test was very satisfactory the pipe was emptied. It showed considerable laitance on the outside and a slight tendency to close up, but leaked too much in the first 24 hours to make a safe pipe for practice.

PIPE NO. 5, TEST 3.

This pipe was now coated inside with two coats of a tufa elastic paint, claimed by the proprietor to be an impermeable material. The first coat was applied July 27; second coat applied August 4.

The results of the third test of pipe No. 5 were as follows:

*Test 3 of pipe No. 5.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Aug. 10 | 11.45 a. m. | ..... | Water turned into pipe. When pipe was nearly full small leak developed at west end. |
| | 3.50 p. m. | ..... | Pipe filled; when air cock was closed pressure raised nearly 25 pounds. Leakage appeared to be at joint near top on south side; also along bottom. |
| | | 30 | Leakage began on north side near top and along bottom. Few leaks on sides and 1 pin hole. Bottom leaked quite freely. |
| | 4.30 p. m. | 34 | General sweat all over pipe. Most leakage along two seams in the bottom. |
| | 5.00 p. m. | 34 | Leakage same. Pressure maintained over night. |
| Aug. 11 | ..... | 30 | Leakage 1¾ gallons per minute. Only two places where there was an appreciable flow except in bottom where there was a strong drip. |
| | 10.30 a. m. | 32 | Leakage 2 gallons per minute. No appreciable change in appearance of pipe. |
| | 11.00 a. m. | 36 | Leakage 2.2 gallons per minute. |
| | | | Before this test was commenced three large cracks were observed on the outside of the pipe, two of them being at the junctions of the top layer with the sides, running the full length of the pipe. The third crack extended one-half the length of the pipe and was in the center of the top layer. None of these cracks showed on the inside, nor did any of them leak under a pressure of 34 pounds. |

Thirty-six pounds pressure seems from the above tests to be a measure of the efficiency of the tufa elastic paint. The same pipe leaked 2½ gallons per minute in test 2 under a pressure of 36 pounds.

When the heads were removed from the pipe it was found that the paint was covered with blisters, ranging from one-eighth to three-fourths of an inch in diameter. There were also many blotches of wrinkled surfaces. As the pipe dried out on the inside a number of surface checks developed, similar to those which occur when paint is put on any surface too thickly.

It must be admitted that all of these tests made on washes or paints gave very poor results; nor is this to be wondered at when it is con-

sidered that a wash or coat of paint is generally so thin that water under pressure is sure to penetrate it sooner or later, unless it were in the nature of a glaze. A glaze, however, being generally put on with heat, is necessarily impracticable for pipes such as are required for use in the Reclamation Service.

## PIPE NO. 6.

### Pipe No. 6, Test 1.

This pipe was coated on the inside east half with a wash of pure cement (Ideal). No wash or coating on west half.

*Test 1 of pipe No. 6.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 9 | 2.15 p. m. | 0 | Water turned into pipe. |
| | 4.00 p. m. | 0 | No leakage in washed section. Pronounced leakage in unwashed section, though not so much as in previous tests at the same stage of filling. Leaks mostly in "tamping seams." Pipe left for the night with small quantity of water flowing in, to soak it up gradually. |
| Mar. 10 | 9.00 a. m. | 0 | Full head city pressure turned on Leakage at imperfect places in unwashed section greater than supply from city main. Pipe emptied for complete inside coating. |

### Pipe No. 6, Test 2.

The pipe leaked so badly during the first test in the unwashed portion that it was impossible to fill it with a hose delivering 11 gallons of water per minute. The west half was covered with two coats of Sylvester wash and cement mixed, and the east half was covered with an additional coat of pure cement wash, which, with the two coats applied in the first test, made three coats of pure cement wash on east half. These coats were applied March 10 and 11. At 8 o'clock on March 16, 1904, water pressure was turned on and the pipe leaked 6 or 7 gallons per minute under 17 pounds of pressure. The leaks were principally through seams, and as they showed no appearance of diminishing by noon the pipe was emptied and the heads were removed to No. 2 for a second test of that pipe. It is quite evident from this test that a wash alone on the inside of a steel concrete pipe is not so effective as a plaster. It is possible, however, that a wash on top of a plaster might be a good thing, and another test will have a bearing on this subject.

PIPE No. 6, TEST 3.

This pipe, when last tested, had on the inside three coats of pure cement wash on east half and two coats of cement mixed with Sylvester wash on west half, and the result of the test being unsatisfactory, on March 21, 1904, another coat of cement mixed to a thick paint with boiled linseed oil was applied, and on March 22 another coat thicker than the first. The two coats required 40 pounds of cement and 5½ gallons of oil.

*Test 3 of pipe No. 6.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| Mar. 26 | 2.00 p. m. | ..... | Pipe filled. No leakage during filling. |
| | | 18 | Strong leakage develops on both sides, where the bottom section joins; remainder of pipe absolutely dry. |
| | 2.00 p. m. | 20 | Same conditions. |
| | 2.40 p. m. | ..... | Slight leakage south side at junction of sides and top section, 5 gallons per minute. |
| | 3.00 p. m. | ..... | Two small leaks on north side near top section. |
| | 3.15 p. m. | ..... | Pressure reduced to 6 pounds. |
| | 3.30 p. m. | 6 | Leakage 2½ gallons per minute. |
| | 4.45 p. m. | 8 | Leakage 2 gallons per minute. |
| Mar. 27 | 4.40 p. m. | 11 | Leakage 1½ gallons per minute. |
| Mar. 28 | 7.45 a. m. | 8 | Leakage 1½ gallons per minute. Full city pressure now turned on. |
| | 8.45 a. m. | 20 | Leakage 4½ gallons per minute. Test unsatisfactory. Pipe emptied. |

It is quite evident to the writer that washes of any kind, unless in the form of a glaze or a soluble glass, are ineffective for making a concrete pipe impermeable. Even if they were effective at first, the coating, being so thin, would soon be worn away by the high velocity of the water, which is necessary for economy in most projects in the reclamation work.

## PIPE NO. 7.

PIPE No. 7, TEST 1.

The pipe was composed of 1 part cement, one-half part lime paste, 3 parts sand, and 6 parts small gravel. It was completed on October 17, 1903, and was well seasoned with water for several days after completion. It remained undisturbed where it was made.

On June 13, 1904, about 100 pounds of fine clay were placed in pipe No. 7 and the heads fastened on the ends of the pipe.

*Test 1 of pipe No. 7.*

| Date. | Hour. | Pressure. | Observations. |
|---|---|---|---|
| | | *Pounds.* | |
| June 13 | 3.30 p. m. | ..... | Water turned in. |
| | 5.00 p. m. | 2 | Pipe commenced to leak on bottom. Inflow reduced to allow the pipe to fill slowly during the night. |
| June 14 | 8.00 a. m. | ..... | Pipe leaking badly. Leakage very muddy from stirring up of clay. Clay stirred all day. |
| | 4.45 p. m. | ..... | Pipe full and leaking like a sieve. |
| June 15 | 8.00 a. m. | ..... | No change. |
| | 5.00 p. m. | ..... | Water turned off; clay stirred. |
| May 16 | 8.00 a. m. | ..... | Water turned on; 3 hours required to fill pipe, showing amount of leakage during night. |
| | 11.00 a. m. | 2 | Pores closed up somewhat. |
| | 2.00 p. m. | 0 | No pressure. Increased leakage. |
| | 5.00 p. m. | ..... | Water turned off for night. |
| June 17 | 8.00 a. m. | ..... | Water turned on. |
| | 10.40 p. m. | ..... | Pipe full, showing less leakage than on previous night. |
| | 10.40 p. m. | 4 | |
| | 10.45 p. m. | 3 | Remained at this pressure all day. Clay stirred constantly. Pressure left on all night. |
| June 18 | 8.00 a. m. | 3 | Considerable laitance. Number of clay streaks on outside of pipe. |
| | 3.30 p. m. | ..... | Pipe emptied. |

This pipe was tested for six days, and the closing up of the pores by lime deposits and clay combined apparently did not raise the pressure more than 3 pounds. During all this time the pipe leaked so badly as to demonstrate its entire unfitness for practical purposes. This experiment will serve to give an idea of the value of clay for stopping up the pores of concrete under the pressure of water.

PIPE NO. 7, TEST 2.

When the heads were removed from the pipe on the completion of the first test, the inside of the pipe was thoroughly washed to remove all traces of the clay, and on June 21 a plaster composed of 1 part cement (Ideal), 1 part marble dust, and 1 part fine screened sand was placed about one-fourth inch thick on the inside surface of the pipe for a length of 17 feet from the east end.

The remaining 3 feet of inside surface at the west end of the pipe was covered with Richards plaster of same thickness (one-fourth inch).

The plaster was kept well moistened till noon, when a thick grouting of equal parts of cement and marble dust was painted over the plaster so as to fill up all the places where the trowel had pulled and a few checks had developed by too quick setting. This plaster and wash was kept well moistened until June 25, when at 1 p. m. the heads were put on and filling commenced.

At 3 p. m. there was great difference between this filling and the previous one, as there was no sign of leakage up to this time, and the pipe was about half filled.

At 5.10 p. m. the pipe was filled, and when the air pipe was closed the pressure slowly rose to 14 pounds, and in a few minutes the pipe leaked freely over most of its surface. Most of the leakage came through the bottom layer, and at 5.25 p. m. the gage had dropped to 11 pounds. The pressure was allowed to remain on full till Monday morning.

June 27, at 8.30 a. m., the gage registered 12 pounds, and the leakage was nearly 7 gallons per minute. The pressure was reduced to 5 pounds, and kept at that for the remainder of the day.

June 28, at 8 a. m., the pressure had risen to 7 pounds during the night, and the leakage amounted to 3 gallons per minute.

The pressure was now turned on full, but the gage rose to only 13 pounds, and in a few minutes dropped to 12 pounds; the bottom leaked as freely as before, though the sides and top did not leak as much as before.

It seems strange that the bottom part of this pipe should leak so badly, as in the other pipes the top and bottom sections, which were tamped in the line of pressure, leaked much less than the sides, which were tamped at right angles to the lines of pressure. The pressure was kept on full until noon, when it was reduced to 5 pounds, and held at that during the balance of the day and night.

On June 29 the pipe dried off a good deal under the reduced pressure, but the bottom leaked freely, and the top was moist in spots, while the sides were practically dry. Considerable laitance had formed where the water had leaked out and run down over the sides.

On June 30 the pressure at 8 a. m. was 7 pounds and there was no material change in the action or appearance of the pipe, and when full pressure was put on the leakage was just as great as before.

The pipe was kept filled and under pressure of about 5 pounds until July 8; the city pressure was turned on occasionally, but the greatest pressure attained during this time was 15 pounds. All of the leakage of consequence was through the bottom section.

As this pipe leaked too much for practical purposes the water was turned off and the experiment concluded.

## SUMMARY OF FIRST 19 TESTS.

In looking over the results of the first 19 tests one thing seems sure—any pipe of this diameter and of great length would have many imperfections, many of which can not easily be avoided. The greater part of the leakage in nearly every case in these tests came from the tamping seams, and by this method of constructing the pipes these seams are almost a necessity. If there are to be seams at all, would it not be better to make them where they can be seen and made tight against leaking, so that more attention may be given to the remainder of the pipe, both in the material of which it is composed and in the placing and tamping of this material afterwards? The great difficulty in the way of making a large pipe of steel concrete continuous is that there are not only longitudinal tamping seams from short delays necessarily incident to this method of construction, but there are in addition cross seams wherever the work may stop for the night or for a day or more, for Sundays, holidays, or on account of bad weather or other unforeseen causes.

This naturally leads to the conclusion that the pipe might be more easily and economically made in short joints, and put together in the trench afterwards. By this means the tamping could be done continuously in each joint, so that there would be no leakage from tamping seams between joints, and special attention could be given to the joints, in order to render them water-tight under ordinary pressure.

A longitudinal seam is much more likely to leak than a vertical seam in pipe under pressure, because the pressure tends to open the longitudinal seam while it does not necessarily tend to open the vertical seam unless the pipe is built on a vertical curve, and this must be guarded against or provided for, if necessary, by taking up the longitudinal strains with steel rods or cables. This method would allow more care to be taken with the mixing and placing of the material and the tamping of it, and would probably result in a much more perfect pipe between joints. There are, however, many practical difficulties in the way of constructing such a pipe of large diameter and great thickness of shell. One of the principal difficulties is to hold the lengths of pipe together till the connection can be made. Another is the handling and placing of such heavy pieces of pipe without injuring them; a third difficulty is that of making a water-tight joint without creating a rough or uneven surface in the waterway.

To put all these matters to a practical test another pipe was constructed during the months of May and June, 1904. This pipe, which is called No. 8, was built in four pieces, each 5 feet in diameter inside, with a shell 6 inches thick, and with steel armor, as in the other pipes, in the center of the shell, and each piece was 5 feet long.

## PIPE NO. 8.

### COMPOSITION.

The composition of the sections of pipe No. 8 is as follows:

Section 1 was composed of Gillingham cement, 4 cubic feet; marble dust, 1 cubic foot; fine sand, 3 cubic feet; gravel, 20 cubic feet; or. 1 part cement, 1 part sand, and 5 parts gravel. The cement and marble dust were mixed through a fine screen, then mixed with the gravel and sand and turned six times dry, then turned four times wet. The concrete was so made that water came to surface after long tamping.

Section 2 was composed of Gillingham cement, 4 cubic feet; marble dust, 1 cubic foot; sand, 3 cubic feet; gravel, 20 cubic feet; lime putty, 3 gallons. The cement and marble dust were mixed as in section 1. Lime putty, passed through fine screens and dissolved in 12 gallons of water, was added during wet mixing. The material was mixed the same number of times as that for section 1, but it was made wetter.

Section 3 had the same composition as section 2, except that to lime putty was added an equal amount of Richards putty.

Section 4 was composed of Ideal cement, 4 cubic feet; marble dust, 2 cubic feet; sand, 4 cubic feet; gravel, 20 cubic feet—well screened and mixed. The material was dry mixed four times, wet mixed three times; 12 gallons of lime putty diluted in 24 gallons of water were added for wet mix.

All of these joints were made by continuous tamping, and every possible care was exercised to produce a good piece of work. They were all well seasoned by constant wetting and protected from the rays of the sun. The sections were made with a projecting bead at one end and a corresponding groove at the other end, so that the bead on one section would fit into the groove on the next section. In addition to this arrangement, a semicircular trench about 1 inch in diameter was left in the bead at one end, and another in the groove at the other end, so that when two sections are placed together these two semicircular trenches will form one circular opening 1 inch in diameter running clear around each joint. When the sections are pulled tightly together this opening can be filled up with cement grout or with any fluid material which may be decided upon as adding to the impermeability of the joint.

Fig. 2 shows the arrangement of sections before joints are closed. These sections were made with the intention of having six longitudinal steel rods run through them, to be fastened with sleeve nuts joining the ends of these rods in adjacent sections, large niches being left on the inside of the pipe at each joint where the sleeve nuts could be tightened. This arrangement would not work satisfactorily and was abandoned for a much simpler one. Through each section of pipe is

un lengthwise six pieces of three-fourths-inch gas pipe, which serve s guides for the rings of steel, to which they may be fastened with opper wire. The sections being all made on one form, these pipes an be kept so closely to their proper position that there is no diffiulty in running a piece of one-half-inch wire cable through them when he sections are placed in position for jointing.

The sections are laid as closely together as may be necessary to llow the mortar for the joint to be put in place between them, and are hen drawn together by fastening cables through a wooden frame at

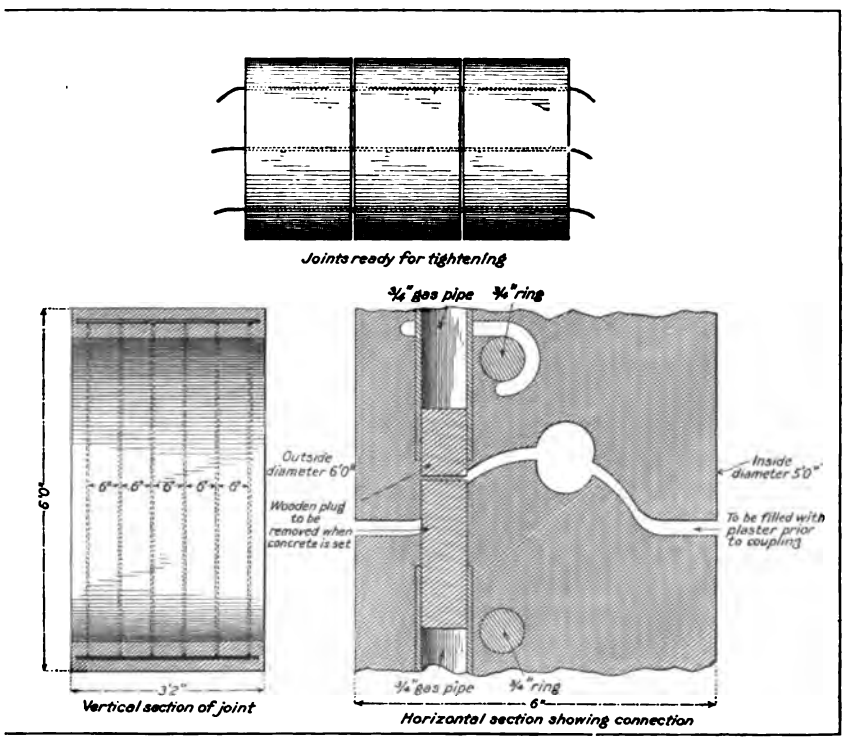



FIG. 2.—Sections of pipe showing methods of connection.

one end of the sections to be joined, and tightening up at the other end by a jackscrew working between two wooden frames, one of which rests against the last section, the other having the ends of the cables fastened to it with clamps, which can be readily removed when the joints are well closed. In the case of pipe No. 8, four sections were tightened up at the same time, and there was no difficulty in bringing the sections together with this length of pipe (20 feet). By this method it would be necessary to have at the end of each 20 feet, or whatever length proved practicable for tightening, a special screw-end rod con-

nection for the cables, about 2 feet long, so that the cable for the next length of pipe might be easily connected with that already tightened. It is most important that the ends of the sections should be made square with the longitudinal axis of the pipe.

PIPE NO. 8, TEST 1.

On July 28, 1904, this pipe, composed of four sections, was filled with water at 11.30 a. m. During the filling section 3 showed a little sweating near the bottom, caused probably by a small crack made while this section was being rolled to its proper place, and all the joints showed a little moisture through the openings that run round the joints and that were recently filled with grout. This grout was composed of 1 part cement, one-fourth part marble dust, and 1 part sand. The joints and niches inside were all filled with Richards mortar. When the air pipe was closed the pressure rose to 15 pounds. Section 1 showed a slight sweat in a short time, but no pinholes, and it was fully half an hour before it became moist over most of its surface. In one hour it was sweating all over.

Section 2 gave about the same results as section 1 until the pressure had been on for ten minutes, when it cracked in three places at the south end for a distance of about 1 foot, and the water leaked out so fast that the pressure would not go above 20 pounds. In one hour the whole surface was sweaty. Section 3 showed sweat developing soon after the pressure was turned on, and in fifteen minutes had a general sweat that at 19 pounds increased to a strong drip.

Section 4 showed absolutely no leakage or sweat for half an hour after being filled, then a slight sweat started on the top, and in one hour this sweat had spread over about one-fourth of its surface. This section was made with Ideal cement.

All the joints sweated a little through the pockets where the grouting was yet fresh and slightly checked, but at no part of the joints did the leakage amount to a flow.

At 2 p. m. there was not much change except that sections 1, 2, and 3 were entirely covered with laitance under a uniform pressure of 18 pounds. Section 4 showed a slight increase of sweat but no laitance except close to the joints, where there was a strong sweat through the pockets.

At 4 p. m. conditions were not materially changed.

At 5 p. m. the pressure was reduced to 8 pounds, and the pipe was left under that pressure all night.

On July 29, at 8 a. m., the gage registered 10 pounds, and as soon as full pressure was turned on it rose to 20 pounds and remained at that for several hours, when it dropped to 18 pounds. There was no change in sections 1, 2, and 3, while section 4 showed a slight sweat

over three-fourths of its surface and no laitance except at the joints. Sections 1 and 2 showed considerably more laitance than section 3.

City pressure was kept on full, and at 5 p. m. no material change was apparent in the pipes, except that section 3 did not seem to drip as much as at first. Section 4 still had one large dry space on each side. The pressure varied all day from 17 to 19 pounds. At 5 p. m. the pressure was closed down for the night to 10 pounds. On July 30, at 8 a. m., the gage registered 12 pounds. When pressure was turned on full it rose to 18 pounds. Section 3 appeared to be closing up and section 4 had not materially changed. By damming up the flow from the pipe and segregating the leakage from section 2, which was badly cracked, it was found that the other three sections leaked nearly 2 gallons per minute.

The water was then turned off and the pipe examined, and it was found that the cracks in section 2 extended clear through. They are supposed to have been caused by the sling which was used when turning the pipes over on their sides with the derrick.

Section 3 showed two checks inside on top, but they did not go clear through.

Sections 1 and 4 showed no cracks on the inside, while section 1 had several checks on the outside.

Section 4 had no checks either inside or outside. The Richards plaster in the inside joints was found to be good and firm and showed no disintegration. Before this pipe was broken up a jackscrew was placed under one end and the pipe was raised until it hung suspended at both ends. The joints were then examined and found to be in good condition. The pipe remained in this position for ten minutes, when the central joint opened one-sixteenth of an inch at the bottom but remained tight at the top. The cables had evidently stretched sufficiently to allow this action. The pipe was broken up about September 27, and it was found that the cracks on the outside on section 1, near the end where the leakage was so great, were caused by the omission of the last steel ring during construction, leaving a space of nearly 1 foot in length at that end without any strength except that of the concrete, which naturally could not stand the strain.

When the joints were broken it was found that there was not as good a bond between the grout and the pipes as there should have been. The core would sometimes adhere to one section of the cavity and make a clean break along the line of the other joint so as to show the shape of the mold. The plaster in the joints should be allowed to harden for at least two days before the grout is forced into the cavity; the grout may be made very wet. The hole should first be filled with water in which a little cement is mixed and allowed to stand filled for an hour, and then blown out and filled with grout.

While this experiment was not at all satisfactory on account of the accident in handling section 2, it shows that, with care and attention to details, this method of constructing pipes might be adopted in case no better one is found.

## SMALL PIPES.

Some further experiments were made for the purpose of ascertaining the best mixtures for impermeable concrete, and for this purpose several small pipes were made with various mixtures and carefully tested.

These smaller pipes were all made in the same mold, each being

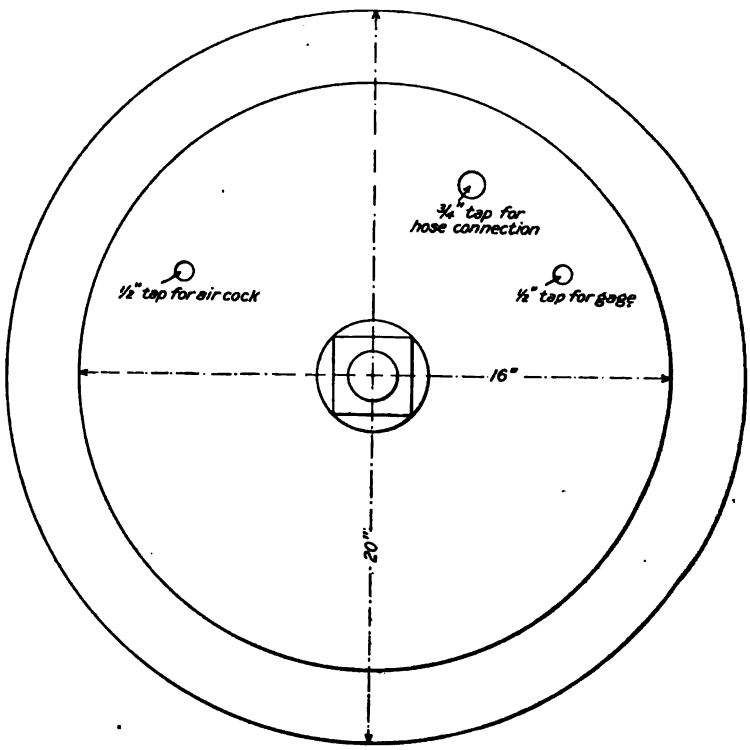



FIG. 3.—Elevation of end of small pipes, with cover, used for determining permeability of different mixtures of concrete.

inches in inside diameter, 6 inches in thickness of shell, and 18 inches long. The ends were made perfectly square to the axis and as smooth and true as possible. To the ends of these pipes were fitted small cast-iron disks, 1 inch thick, resting upon rubber-tire washers, vulcanized at the junction of the ends. The plates were drawn tightly on the washers by one central rod with a screw end to which a nut was fitted, substantially as shown in figs. 3 and 4.

The upper plate had connections for pipe from water tap, for air, and for gage as in the larger pipes.

Three of these pipes were made of each mixture, and nine different mixtures were tested. The three pipes for each mixture were marked "A," "B," and "C," respectively.

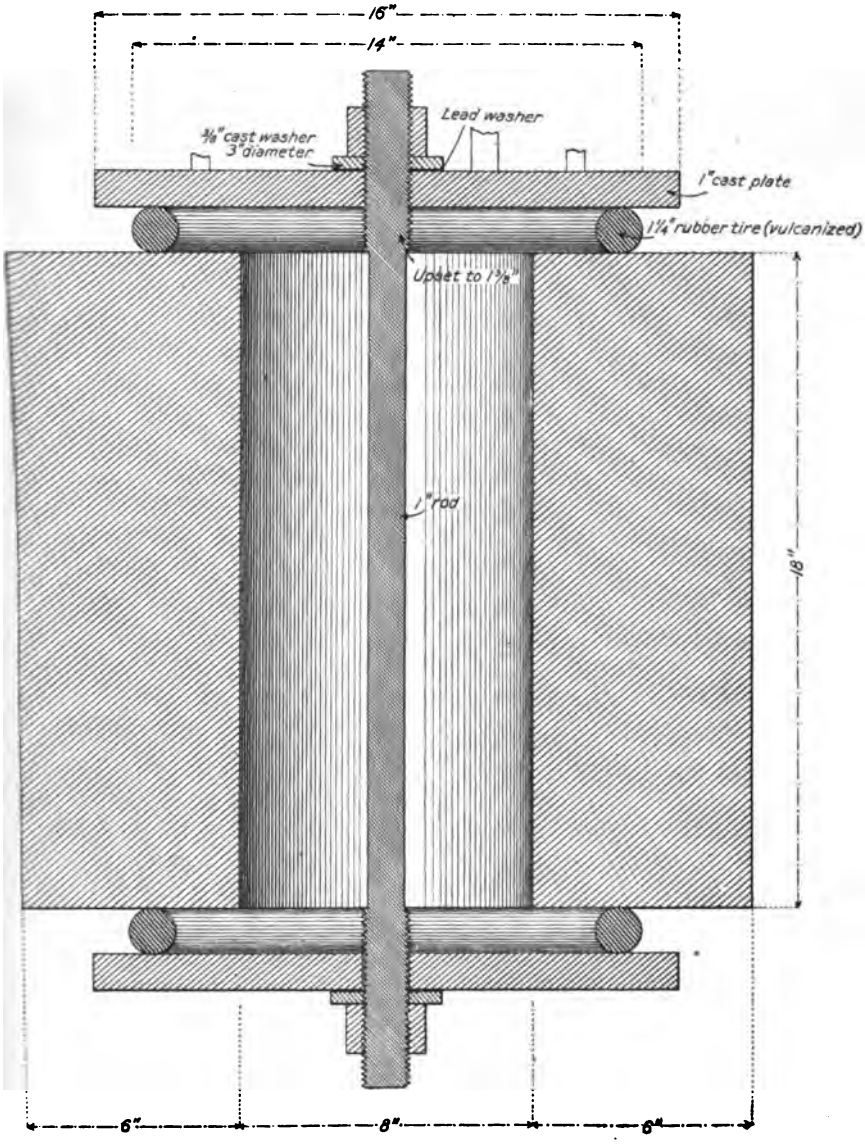



FIG. 4.—Horizontal section of small pipes used for determining permeability of different mixtures of concrete.

Mixture No. 1 consisted of sand 2 parts (screened through 14-mesh screen), gravel 3 parts (mixed sizes), cement (Ideal) 1 part, and marble dust 1 part—all measured loose.

PIPE A, MIXTURE NO. 1.

This pipe was made August 17, and brushed inside and out with a cement wash. It was kept well wet for several days until thoroughly seasoned. On October 19 water was turned on, the pressure varying from 40 to 56 pounds for six hours. During this time the pipe showed no sweat or leak, but in one of the sudden jumps of the pressure from 40 to 60 pounds the pipe burst and stopped the test. Owing to the fluctuation of the pressure in the water pipes this was not a very satisfactory test, but showed incidentally that the tensile strength of this mixture was at least 40 pounds per square inch.

PIPE B, MIXTURE NO. 1.

This pipe was made on August 17. It was not washed with cement inside or outside, but was kept moist for three weeks and remained in the shade till October 20, when it was tested.

At 8.30 a. m. water was turned on and pressure allowed to rise to 40 pounds, and maintained as near that point as possible. In one hour a slight sweat showed near the bottom, and in four hours this sweat had spread over most of the surface. The pressure was then allowed to rise to 55 pounds, and a general sweat spread over the entire surface. This pressure was maintained for two hours more, and then the pipe burst during a sudden fluctuation of pressure from 45 to 62 pounds.

It was now decided to use two steel bands for clamping around the pipes during the tests, to prevent the bursting of the pipe under water hammer.

PIPE C, MIXTURE NO. 1.

This pipe was made August 18, and kept in the shade and well moistened until October 20, when it was tested. It was not washed with cement. At 3 p. m. water was turned on and the pressure regulated to 30 pounds. There was a flaw in the inside of this pipe caused by the material sticking to the core when the latter was being drawn out. The water seemed to enter this flaw, and caused a sweat at that place, and in two hours this sweat had spread over most of the surface of the pipe. At 5 p. m. the pressure was turned off and the pipe left filled with water for the night.

On October 21 the pressure was kept at 35 pounds from 8 till 10 a. m. The pressure was raised to 45 pounds, fluctuating between 43 and 55 pounds for two hours, during which time the pipe leaked 7½ gallons of water. The outside bands were now put on the pipe and the full city pressure turned on. The gage fluctuated between 43 and 62 pounds for the remainder of the day and until next day at noon, but there was no apparent increase in the amount of leakage. This pipe was not in good condition, but was tested for the sake of trying

the effect of the steel bands on the outside in preventing bursting under fluctuating heads. In this case they seemed to answer the purpose, but in many of the succeeding tests they did not prevent the pipes from bursting under much lower heads.

As the object of the experiments was to ascertain at what pressure sweating commenced, and as this point was in nearly all cases less than 40 pounds, the breaking of the pipe at a higher pressure than this was not of so much consequence.

The composition of the various mixtures and the pressure at which the sweating first became visible are shown below.

RESULTS OF TESTS OF SMALL PIPES.

It is not claimed that these pipes would not have sweated and leaked under lower pressures maintained for a long time; but in nearly every instance the sweating showed at the recorded pressure inside of one hour from the time the water was turned on.

*Mixture No. 1.*—Sand 2 parts, gravel 3 parts, cement 1 part, marble dust 1 part.
Pipe A, no sweat under 55 pounds (washed inside and out with cement wash).
Pipe B, sweat at 40 pounds (not washed with cement).
Pipe C, sweat at 30 pounds (not washed and had flaw inside).
*Mixture No. 2.*—Sand 3 parts, gravel 4 parts, cement ⅔ part, marble dust 1⅓ parts.
Pipe A, sweat at 60 pounds (washed inside and out with cement wash).
Pipe B, sweat at 45 pounds (not washed with cement).
Pipe C, sweat at 30 pounds (washed on inside with cement).
*Mixture No. 3.*—Sand 3 parts, gravel 4 parts, cement ⅔ part, marble dust 1⅓ parts, lime putty ½ part.
Pipe A, sweat at 35 pounds (washed inside and outside with cement).
Pipe B, sweat at 30 pounds (not washed).
Pipe C, sweat at 30 pounds (washed inside with cement).
*Mixture No. 4.*—Sand 3 parts, gravel 4 parts, cement 1½ parts, hydrated lime ½ part.
Pipe A, sweat at 30 pounds (washed inside and out with cement).
Pipe B, sweat at 35 pounds (not washed).
Pipe C, sweat at 35 pounds (washed inside with neat cement).
*Mixture No. 5.*—Sand 3 parts, gravel 4 parts, cement 1 part, marble dust 2 parts, lime putty ¼ part.
Pipe A sweat at 50 pounds (washed inside and out with neat cement).
Pipe B sweat at 35 pounds (no wash).
Pipe C sweat at 40 pounds (washed inside with neat cement).
*Mixture No. 6.*—Sand 2 parts, gravel 5 parts, cement 1 part, marble dust 1 part, Richards mixture 1 part.
Pipe A sweat at 40 pounds (not washed).
Pipe B sweat at 40 pounds (not washed).
Pipe C broke at 40 pounds. Without sweat for 45 minutes. (Not washed.)
*Mixture No. 7.*—Sand 2 parts, gravel 5 parts, cement 1 part, marble dust 1 part, lime putty ½ part (with Richards mixture).
Pipe A sweat at 35 pounds (no wash).
Pipe B sweat at 38 pounds (no wash).
Pipe C sweat at 40 pounds (no wash).
*Mixture No. 8.*—Sand 2 parts, gravel 5 parts, cement 2 parts, hydrated lime ½ part, marble dust ½ part.

Pipe A sweat at 35 pounds (no wash).

Pipe B sweat at 23 pounds (no wash).

Pipe C sweat at 23 pounds (no wash).

*Mixture No. 9.*—Sand 2 parts, gravel 5 parts, cement 1½ parts, hydrated lime ½ part, marble dust 1 part.

Pipe A sweat at 40 pounds (no wash). This pipe stood 65 pounds without breaking.

Pipe B sweat at 41 pounds (no wash). This pipe stood 57 pounds' pressure without breaking.

Pipe C discarded on account of flaw.

It is evident from these experiments that the impermeability of the concrete itself in a steel-concrete pipe must not be depended on too much, but it is better to cover the inside surface of the pipe with a thick coat, or probably better still with several thin coats of impervious mortar. This mortar must be soft and plastic when first placed on the pipe. The Richards plaster seems to be the nearest approach to this ideal plaster that has been found in these experiments.

The experiments on the small pipes were not carried out by the writer, who, on account of other duties, was unable to direct them. The assistant in charge of the experiments was a very careful, painstaking, and practical man of long experience in concrete work, and the experiments are given for what they are worth.

This entire subject is a most complex one, and it is realized that the results of these experiments are somewhat disappointing. It is hoped, however, that what little has been done may serve as a beginning for further experiments.

## CONCLUSIONS.

The following precautions in making concrete pipes to withstand water pressure are suggested:

1. Do not allow the sun's rays to touch the concrete when it is being mixed and placed in the form. If necessary build a shed over the work.

2. If the steel-concrete pipe can not be made continuously by machine, do as much of the hand tamping as possible in radial directions. When the tamping must be done at right angles to the radius of the pipe, either in longitudinal or circumferential directions, avoid as far as possible the formation of seams or cleavage planes from delays in placing the forms and adding fresh material. By making the concrete very wet, delays will not be so dangerous as in the case of dry concrete.

3. Be careful in tamping not to spring the longitudinal rods, and use as few of these as will suffice to hold the circumferential rods in place, except in case of vertical curves in the pipe, when additional rods or steel cables must be used on the longer side of the curved part of the pipe.

4. Do not depend upon the tensile strength of the concrete, but

make the steel rods of such size and distance apart as will insure no greater stretch of the steel than 0.04 inch in any rod from the maximum pressure to which the pipe is to be subjected.

5. Make the inside diameter of the pipe 1½ inches larger than required, to allow space for putting two coats of plaster on the inside.

6. As soon as the pipe is completed give the inside one coat of plaster one-half inch thick, composed of 1 part cement to 1½ parts of sand, and a small quantity of lime paste, thoroughly cooled, to retard setting. Keep pipe well wet ahead of the plastering. When this coat, which may be left rough, is dry, put on another coat about one-fourth inch thick of plaster composed of 1 part of sand to 1 part of cement. This coat should be troweled to a smooth surface, and when it is dry the entire inside surface of the pipe should be covered with a thick wash of fine cement and water.

7. Provide for drainage of water which may leak when the pipe is first filled, so that sufficient water may not remain in the trench to soften the ground under the pipe.

8. Bury the pipe under the ground so that there will be in no place less than 2 feet between the top of the pipe and the natural surface of the ground.

9. In very cold climates provide means for draining the pipe, so that it can be emptied at the end of each irrigating season.

10. The soap and alum mixture may be used to advantage in making the concrete, but reliance for impermeability must be placed on the plastering rather than on the material of the pipe.

11. Do not use steel-concrete pipes for heads over 70 feet, except for short distances, where a 100-foot head might be used by taking special precautions.

It may be asked why, in view of the fact that a head of 70 feet is likely to crack a 5-foot steel-concrete pipe, it is recommended to build pipes of such diameter, for use under such a head. It may be answered that a steel-concrete pipe with a crack and a small, gradually decreasing leakage may be, and probably is, much more durable than a pipe made of steel, or of wood with steel bands or rods, and the leakage, under ordinary circumstances, may not be as much as is now found in many lines of cast-iron pipes in our large cities.

Under ordinary conditions, in all of the reclamation projects where pressure pipes may be used, the pipes will probably be under uniform pressure for all of the irrigating season. It is highly probable that cracks formed in these pipes when under pressure will be filled up with sediment and lime deposits during the irrigating season, which generally lasts several months. If serious leaks occur during this season, the blow-off and drain pipes can be used to turn the water out of the pipe, so that it can be repaired inside, and during the winter

time, when the pipe is empty, an excellent opportunity is afforded to examine and make repairs in the inside of the pipe.

A 5-foot pipe under 30 pounds pressure, or approximately 70 feet head, if made with 1-inch rods, instead of three-fourths-inch rods, with 3⅜-inch center distances, would cost about $2.50 a foot extra, and the only gain would be that the stretch of the steel would be 0.023 inch, instead of 0.040 inch for the three-fourths-inch rods. Theoretically, when steel-armored concrete pipe is subjected to internal pressure, the materials of which it is composed must yield or stretch within certain limits. As the stretch of concrete is so small that it has never been measured, we must rely upon the steel to take up the stresses caused by the internal pressure in the pipe. If a steel-concrete pipe is designed to bear with safety 30 pounds per square inch internal pressure, and the steel in the pipe is calculated to take up all the stress due to this pressure, with a factor of safety of 4 for steel of an ultimate strength of 60,000 pounds, and if the pipe is 5 feet diameter inside, and the steel rods three-fourths-inch diameter, these rods would have to be spaced 7.33 inches from center to center.

Let us determine what the stretch in this steel would be in one rod under these conditions.

The stretch in inches = total stress in pounds on 7.33 inches in length of pipe × original length in inches ÷ modulus of elasticity in pounds per square inch × area in square inches; therefore stretch =

$$7.33 \times 30 \times 30 \times \frac{204}{35{,}000{,}000 \times 0.44} = 0.09 \text{ inch nearly.}$$

It is probable that this amount of stretch in the steel would cause one or more cracks along the full length of the pipe. If, however, the amount of steel is doubled, the stretch would be reduced by one-half, but this makes the pipe more expensive.

There would still be a stretch of 0.04 inch, and the consequences of this stretch might be guarded against by plastering with some material which would be more plastic than ordinary concrete, or by another method mentioned hereafter.

If this steel were distributed over the full length of the pipe in the shape of a sheet-steel riveted pipe, it would give thickness of $\frac{0.44}{3.66} = 0.12$ inch for the steel, and this pipe, if double riveted, would have a factor of safety of 5.6. This thickness is really more than is necessary for safety, but not more than is necessary for rigidity of form in a steel pipe of 5 feet diameter if used alone, nor for a steel-concrete pipe under the assumed pressure if the stretch is taken into account.

There can be no question that a steel pipe inside a concrete pipe would be tight, but it would be useless to put a lining of concrete inside the steel, as the concrete would certainly leak some, and the steel would be little better protected on the inside from the action of the water

than if there were no concrete inside. It would, however, be protected from scouring, and a ring of concrete outside the steel would protect the outside of the steel from the action of injurious salts, acids, etc. A better pipe, however, would be a wooden pipe with steel bands, which can be made perfectly continuous, smooth, and true inside, with a ring of concrete placed around it after the wood is thoroughly saturated and the leaks all closed up. This would be an expensive pipe, but it is believed that it would be as nearly an ideal pipe for a warm climate as could be made. With a factor of safety of 4 for the steel rods, the amount of steel would be reduced to half of that in the concrete pipe, and in the case of 30 pounds pressure this would amount to a three-fourths-inch rod 17 feet long for each 7.33 inches in length of the pipe, or $\frac{17\times1.5\times12}{7.33}=41$ pounds of steel per linear foot of pipe.

Concrete in a ring 3 inches thick around wood pipe would amount to $\frac{18}{4}=4\frac{1}{2}$ cubic feet per linear foot, so that the amount of money saved on the steel by using a wooden pipe would probably pay for the concrete used in covering it.

For a comparison of cost, then, we could have a wooden pipe with bands spaced for a factor of safety of 4, and 3 inches of concrete outside, as against a steel-concrete pipe with twice the number of bands and 6 inches of concrete. With steel at 4 cents per pound in place, concrete at 40 cents per cubic foot in place, and lumber at 7 cents per foot B. M. in place, the cost of these pipes would be about the same, and there is little doubt that the wooden pipe with a concrete envelope would be the better and more lasting pipe.

Another method for getting rid of the injurious effect of the stretch in the steel in a steel-concrete pipe (with a factor of safety of 4 for the steel rods) would be to make two well-defined joints in the concrete in a horizontal plane through the center and running the full length of the pipe.

A continuous sheet-steel dowel could project 2 or 3 inches into the concrete in each half of the pipe, and when the pressure came on the inside the stretch would probably take place at these joints and thus prevent all other longitudinal cracks from forming.

This dowel, which might be one-eighth by 6 inches, could be made in long lengths, overlapping a little at the ends and fastened by wire to the rods to keep it in its proper place. The concrete in the lower half of the pipe would end in a smooth, horizontal plane at the center line of this dowel on each side, and this plane might be allowed to harden for twenty-four hours, so that when the upper half of the pipe was made there would be a well-defined crack on each side. Of course this would increase the area subject to inside pressure by a small amount on each side, but this would be true of any other longitudinal crack.

It seems probable that this would prevent any other cracks forming, but it would be necessary to try this experiment before building any large amount of pipe on this assumption.

The durability of steel rods of large diameter, such as were used in these experiments, is yet undetermined, as the time between placing these rods in the concrete and the breaking up of the pipes was too short to afford reliable data for conclusions on this subject.

When the pipes were broken up none of the rods exhibited any appearance of rust, except one, which showed, at a point where there was a large and long-continued leak in the pipe, a small rusty place, about 1½ inches long, all around the rod. The pipe in which this occurred was lined with a mortar mixed with sal ammoniac and iron filings, and the presence of the sal ammoniac would naturally account for the rust.

Instead of steel rods electrically welded galvanized wire might be used for armor in concrete pipe. This wire is now manufactured in the United States, and could be used if the pipe were made in joints. It would not be suitable, however, if the pipe were made continuously, as in these experiments, on account of the difficulty of tamping and the stretch of the steel, and the consequent cracking of the concrete would still occur, so that the amount of wire needed in the hoops would probably make it too expensive to be considered.

If many of the results of these experiments have been negative, it may be some consolation to remember that it is sometimes quite as important to know how *not* to do a thing as to know how to do it.

# INDEX.


Page.

Alkali soil, effect of, on steel pipe..... 9, 10
Alum, use of..... 14
use of, advantage in..... 55
in plaster lining..... 19
Annales des Ponts et Chaussées, paper by M. R. Feret in..... 12
Ashes, test of, in stopping leaks..... 37
use of, inside pipe..... 32
Cement, Gillingham, use of..... 13, 14, 46
Cement, Ideal, use of, in pipes..... 14, 15, 46, 51
use of, in plaster..... 31, 43
in wash..... 41
Clay, effectiveness of, in closing pores..... 43
test of, in stopping leaks..... 37
use of, inside pipe..... 37, 42
to render pipes impervious..... 25
Climate, effect of, on wooden pipe..... 10
Coal tar, use of, in plaster..... 36
Composition of pipe made in sections..... 46
of plaster linings..... 18, 19, 21
of small pipes..... 51, 53
of tested steel-concrete pipes..... 13–15
Conclusions from experiments..... 54–58
Concrete, composition of, in pipe..... 13–15, 46
discussion of, in Proc. Am. Soc. Civ. Eng. 12
first test of..... 20
how injured by sun's rays..... 36, 54
method of tamping..... 16, 54
mixing of, in making pipes..... 17, 46
porosity of..... 11
tensile strength of..... 30, 54
test of impermeable mixtures for..... 50
use of soap in..... 13
Construction of pipe in sections..... 47
of pipes, suggestions for..... 57
of steel-concrete pipes..... 11–17
Cost, computation of, for different pipes... 57
Crack, repair of, on pipe..... 26
Cracks, cause of, along tamping seams..... 36
in interior of pipes, nature and cause of..... 20, 24
Disk, details of, view of..... 18
Disks ready for test, view of..... 16
use of, in testing pipes..... 17, 18
Drainage from leakage provided for..... 55
of pipes in cold weather..... 55
Dry mixture, use of, in pipe..... 20
Durability of steel pipe..... 9, 10
of steel rods..... 58
Efflorescence, deposition of, on concrete pipes under water pressure..... 11, 12
Elastic lining, need of..... 20
Elastic paint, use of, on pipe..... 40

Page.

Elastic plaster, need of..... 30
Elevation of end of small pipes..... 50
Feret, M. R., paper by, on porosity of concrete..... 12
Filings, iron, use of..... 29
Freezing, provision against..... 55
to be avoided in wooden pipe..... 10
Gas pipe, use of, in concrete pipe..... 47
Gillingham cement, use of, in pipes..... 13, 14, 46
Glaze, need of, inside pipes under pressure. 41, 42
Gravel, porosity in mixture of..... 20
Grout, composition of, in pipe..... 48
effectiveness of, in joints of pipe..... 49
use of, to cement joints..... 46
Head of water, limit of, for steel-concrete pipes..... 55
Ideal cement, use of..... 14, 15, 31, 41, 43, 46, 51
Impermeability, how obtained in joints... 49
increase of, with age..... 32, 34
test of, in small pipes..... 50, 53
Iron, use of, in wash..... 39
Iron filings, advantage of use of..... 29
use of, in plaster..... 29
Iron oxide, formation of, on outside of pipe. 34
Iron water, use of, in wash..... 31
Joints, how rendered impermeable..... 46, 49
tightening of, by wire..... 58
Laitance, composition and occurrence of.. 12
effect of, on pipes..... 21
occurrence of, on pipes..... 20, 23, 24, 39, 44, 49
Leakage, amount of, in pipes without plaster..... 28
cause of, along tamping seams..... 36
drainage of, provided for..... 55
effect of clay in stopping..... 37, 43
general origin of..... 45
measurement of..... 24, 25
by weir..... 24
possible effect of, on foundation of pipe. 20
reduction of, by time..... 20
variance of, in different pipes with same pressure..... 27
Lesley, R. W., on construction of concrete pipe..... 12
Lime, advantage of, in applying plaster... 29
effectiveness of, in closing pores..... 43
Linings, plaster, composition of..... 18, 19, 21
effectiveness of..... 20
Linseed oil, use of, in plaster..... 36
Los Angeles, construction of pipes at..... 13
McIntyre, J. B., on permeability of concrete..... 12
Mixing, method of, in making concrete.... 17, 46

Page.
Mixture, dry, use of, in pipe ..... 20
Paint, effectiveness of, inside of pipes under pressure ..... 41
Paint, elastic, use of, on pipe..... 40
Paint, P. and B., use of..... 21, 35
Paint, waterproof, use of ..... 21
effectiveness of ..... 35, 36
Permeability of concrete pipe, McIntyre and True on..... 12
Pipe, construction of, in sections..... 46, 47
construction of, method of, view of .... 14
end of, being raised, view of..... 20
section of, showing direction of tamping ..... 16
sections of, showing method of connection..... 47
under test, view of ..... 20
with disks set ready for test, view of... 16
Pipe, concrete, permeability of..... 12
Pipe, steel, durability of..... 9, 10
Pipes, cost of, computed..... 57
cracks inside of..... 20, 24
draining of, in cold weather ..... 55
effect of velocity of water on ..... 42
method of finishing, view of ..... 16
methods suggested for construction of . 57
mixing of concrete for..... 17, 46
placing of, underground ..... 55
under pressure, need of glaze in..... 41, 42
use of clay in ..... 37, 42
Pipes, concrete, necessity of plaster for..... 28, 54
Pipes, pressure, different kinds used ..... 9–11
need of, in Reclamation Service..... 9
Pipes, small, construction of ..... 50–53
effect of water hammer on ..... 52
elevation of end of, figure..... 50
horizontal section of..... 51
*See also* Steel pipes; Steel-concrete pipes; Wooden pipes.
Plaster, advantage of softness in ..... 27
method of applying ..... 55
necessity of use of ..... 28, 54
use of alum in ..... 19
use of coal tar in..... 36
use of iron filings in..... 29
use of lime with ..... 29
use of linseed oil in..... 36
use of sal ammoniac in..... 29
use of soap in..... 19
Plaster, elastic, need of..... 30
Plaster, Richards, effectiveness of..... 54
use of..... 25, 26, 39, 43, 46, 48, 49
Plaster, waterproof, test of ..... 38
Plaster linings, composition of..... 18, 19, 21
effectiveness of..... 20
Porosity, effect of clay on ..... 43
effect of lime on..... 43
in concrete ..... 11
of concrete, paper by Feret on ..... 12
of mixture of gravels of different sizes . 20
relation of, to leakage ..... 27
Pressure, effect of, on different porosities .. 27
effect of, on paint ..... 41
on steel rods..... 56
on wash ..... 41
in city water mains, change of..... 22
Pressure, measure of bursting force of..... 3
taken up by steel rods..... 9
use of, from water mains..... 20, 22
Pressure pipes, different kinds used..... 9–11
need of, in Reclamation Service ..... 9
Pump, use of, on pipe ..... 27
Pumps, little used in testing ..... 21
Reclamation Service, use of pressure pipes in ..... 9
Richards, C. E., presence of, at test of his plaster..... 25
wash and plaster of ..... 25
Richards plaster, effectiveness of ..... 54
use of ..... 25, 26, 39, 43, 46, 48, 49
Rod, central, view showing, with details .. 18
Rods, longitudinal, care of, in tamping.... 54
cracks along..... 37
Rods, steel, durability of ..... 56
effect of sal ammoniac on..... 34
factors of safety in ..... 56, 57
pressure on..... 4
proper size of, in steel-concrete pipe ... 7
stretch of, under pressure..... 56
Rubber gasket, accident to ..... 22
use of, on pipes..... 17, 18
Safety, factors of, in steel rods ..... 56, 57
Sal ammoniac, effect of, on steel rods..... 34
use of, in plaster ..... 29
in wash .....
Sanders, W. H., supervision of construction of pipes by..... 13, 6
Sections, horizontal, of small pipes ..... 51
Small pipes. *See* Pipes, small.
Soap, use of, advantage in ..... 35
use of, in pipe ..... 13
in plaster lining..... 19
Steel pipe, comparison of, with steel-concrete pipe ..... 55
effect of soil on ..... 9, 10
construction and use of ..... 9, 10
Steel rods. *See* Rods, steel.
Steel-concrete pipes, apparatus for testing of..... 17, 18
comparison of, with steel pipe and wooden pipe ..... 55
composition and construction of ..... 11–17
composition of those tested ..... 13–15, 46
disadvantages of ..... 11
limits of water head for..... 55
method of construction of..... 15–17
relations of porosity, pressure, and leakage in ..... 27
tamping of, in constructing..... 16, 54
Stretch in steel, injury from, avoided..... 57
in steel rods ..... 56
Stuffing box, use of, inside pipe to stir clay. 37
Sun, effect of, on concrete under construction..... 36
injury from, in constructing concrete.. 54
Sylvester wash, effectiveness of, in concrete pipe ..... 29
effectiveness of, on inside of pipe ..... 35, 36
use of..... 21, 24, 35, 41
Tamping, direction of, section showing.... 16
method of, in concrete pipe ..... 54
in steel-concrete pipes..... 16

Page.
Tamping seam, cause of leak from..... 36
causing of cracks by..... 13, 30
leakage from..... 45
longitudinal and vertical compared.... 45
necessity of, in construction of large pipes..... 45
plan for avoidance of..... 45
Test pipes, composition of..... 13–15
Tests, apparatus used for..... 17, 18
composition of pipes for..... 13–15
of small pipes, object of..... 53
of steel-concrete pipes..... 18–49
summary of..... 45
True, A. L., on permeability of concrete... 12
Tufa elastic paint, use of..... 40
Underground position of pipes..... 55
Velocity, probable effect of, in water pipes. 42
Wash, directions for applying, by Trautwine..... 35
effectiveness of, inside of pipes under pressure..... 41
use of, without plaster..... 41

Page.
Wash, use of iron water in..... 31, 39
use of sal ammoniac in..... 31
Wash, waterproof, test of..... 38
*See also* Sylvester wash.
Water, penetrating power of..... 11
Water hammer, effect of, on small pipes... 52
Water mains, change of pressure in, during day..... 22
of city, use of pressure from..... 20
Water pressure, efflorescence from..... 11, 12
limit of, for steel-concrete pipe..... 55
Waterproof material in concrete, test of... 28
Waterproof paint, effectiveness of, inside of pipe..... 35, 36
Waterproof wash and plaster, test of..... 38
Weir, use of, to measure leakage of pipe... 24
Wire, use of, in jointed pipe..... 58
Wire cable, use of, in pipe..... 47
Wooden pipe, advantages of..... 57
comparison of, with steel-concrete pipe. 55
construction and use of..... 10, 11
effect of climate on..... 10

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# PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Water-Supply Paper No. 143.]

The publications of the United States Geological Survey consist of (1) Annual Reports; (2) Monographs; (3) Professional Papers; (4) Bulletins; (5) Mineral Resources; (6) Water-Supply and Irrigation Papers; (7) Topographic Atlas of United States—folios and separate sheets thereof; (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists may be had on application.

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1. A limited number are delivered to the Director of the Survey, from whom they may be obtained, free of charge (except classes 2, 7, and 8), on application.

2. Every member of Congress is allotted a certain number, from whom they may be obtained, free of charge, on application.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they may be had at practically cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they may be consulted by those interested.

The Professional Papers, Bulletins, and Water-Supply Papers treat of a variety of subjects, and the total number issued is large. They have therefore been classified into the following series: A, Economic geology; B, Descriptive geology; C, Systematic geology and paleontology; D, Petrography and mineralogy; E, Chemistry and physics; F, Geography; G, Miscellaneous; H, Forestry; I, Irrigation; J, Water storage; K, Pumping water; L, Quality of water; M, General hydrographic investigations; N, Water power; O, Underground waters; P, Hydrographic progress reports. This paper is the eighteenth in Series I, the complete list of which follows (all are Water-Supply Papers thus far).

SERIES I—IRRIGATION.

WS 2. Irrigation near Phoenix, Ariz., by A. P. Davis. 1897. 98 pp., 31 pls. and maps. (Out of stock.)
WS 5. Irrigation practice on the Great Plains, by E. B. Cowgill. 1897. 39 pp., 11 pls. (Out of stock.)
WS 9. Irrigation near Greeley, Colo., by David Boyd. 1897. 90 pp., 21 pls. (Out of stock.)
WS 10. Irrigation in Mesilla Valley, New Mexico, by F. C. Barker. 1898. 51 pp., 11 pls. (Out of stock.)
WS 13. Irrigation systems in Texas, by W. F. Hutson. 1898. 68 pp., 10 pls. (Out of stock.)
WS 17. Irrigation near Bakersfield, Cal., by C. E. Grunsky. 1898. 96 pp., 16 pls. (Out of stock.)
WS 18. Irrigation near Fresno, Cal., by C. E. Grunsky. 1898. 94 pp., 14 pls. (Out of stock.)
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WS 32. Water resources of Porto Rico, by H. M. Wilson. 1899. 48 pp., 17 pls. and maps. (Out of stock.)
WS 43. Conveyance of water in irrigation canals, flumes, and pipes, by Samuel Fortier. 1901. 86 pp., 15 pls. (Out of stock.)
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WS 93. Proceedings of first conference of engineers of the Reclamation Service, with accompanying papers, compiled by F. H. Newell, chief engineer. 1904. 361 pp.

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WS 143. Experiments on steel-concrete pipes on a working scale, by J. H. Quinton. 1905. 61 pp., 4 pls.

The following papers also relate especially to irrigation: Irrigation in India, by H. M. Wilson, in Twelfth Annual, Pt. II; two papers on irrigation engineering, by H. M. Wilson, in Thirteenth Annual, Pt. III.

Correspondence should be addressed to

THE DIRECTOR,
UNITED STATES GEOLOGICAL SURVEY,
WASHINGTON, D. C.

July, 1905.

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Author.

Quinton, John H. 1850–

. . . Experiments on steel-concrete pipes on a working scale, by John H. Quinton. Washington, Gov't print. off., 1905.

61, iii p. illus., IV pl. 23cm. (U. S. Geological survey. Water-supply and irrigation paper no. 143)
Subject series: I, Irrigation, 18.

1. Pipes.

Subject.

Quinton, John H. 1850–

. . . Experiments on steel-concrete pipes on a working scale, by John H. Quinton. Washington, Gov't print. off., 1905.

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Subject series: I, Irrigation, 18.

1. Pipes.

Series.

U. S. Geological survey.

Water-supply and irrigation papers.
no. 143. Quinton, J. H. Experiments on steel-concrete pipes on a working scale. 1905.

Reference.

U. S. Dept. of the Interior.
see also
U. S. Geological survey.

Water-Supply and Irrigation Paper No. 144 Series L, Quality of Water, 10

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

# THE NORMAL DISTRIBUTION OF CHLORINE IN THE NATURAL WATERS OF NEW YORK AND NEW ENGLAND

BY

DANIEL D. JACKSON

WASHINGTON
GOVERNMENT PRINTING OFFICE
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# CONTENTS.


| | Page. |
|---|---|
| Letter of transmittal | 7 |
| Introduction | 9 |
| Physiological functions of common salt | 9 |
| Salt as an indication of pollution | 9 |
| Salt in the waters of inland States | 10 |
| Salt in coast State waters | 10 |
| Collection of samples | 11 |
| Solutions required for chlorine determinations | 11 |
| Salt solution | 11 |
| Silver nitrate solution | 11 |
| Potassium chromate solution | 11 |
| Emulsion of alumina | 11 |
| Methods of procedure in the determination of chlorine | 12 |
| Observations on the use of the normal chlorine map | 12 |
| History of normal chlorine work | 13 |
| The isochlors of Maine | 13 |
| Chlorine determinations for Maine | 14 |
| The isochlors of New Hampshire | 15 |
| Chlorine determinations for New Hampshire | 16 |
| The isochlors of Vermont | 18 |
| Chlorine determinations for Vermont | 19 |
| The isochlors of Massachusetts | 20 |
| Chlorine determinations for Massachusetts | 21 |
| The isochlors of Rhode Island | 22 |
| Chlorine determinations for Rhode Island | 22 |
| The isochlors of Connecticut | 22 |
| Normal distribution of chlorine in Connecticut | 22 |
| Averages of chlorine determinations on which the map is based | 23 |
| Chlorine determinations for Connecticut | 24 |
| The isochlors of New York | 28 |
| Chlorine determinations for New York | 29 |
| Index | 33 |

# ILLUSTRATIONS.


| | | Page. |
|---|---|---|
| PLATE I. | Normal chlorine map of New England and New York | 12 |
| II. | The normal distribution of chlorine in Maine | 14 |
| III. | The normal distribution of chlorine in Vermont and New Hampshire | 16 |
| IV. | The normal distribution of chlorine in Massachusetts, Rhode Island, and Connecticut | 20 |
| V. | The normal distribution of chlorine in the State of New York | 28 |

# LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
HYDROGRAPHIC BRANCH,
*Washington, D. C., December 20, 1904.*

SIR: I transmit herewith a manuscript entitled "The Normal Distribution of Chlorine in the Natural Waters of New York and New England," by Daniel D. Jackson, and request that it be published in the series of Water-Supply and Irrigation Papers.

There is probably no more important feature involved in the establishment of municipal water supplies in States bordering on or situated close to the seacoast than the determination of normal chlorine. The availability of any water for such purposes depends largely upon its freedom from organic contamination. Chlorine is one of the ingredients of dangerous organic matter, and, as this element is extremely stable, it undergoes none of the chemical changes common to the other component parts of organic matter, and its determination furnishes reliable and persistent evidence concerning the pollution of any water.

A certain proportion of the chlorine in a water has its origin in natural causes, and has no relation to artificial pollution; therefore, in determining the character of a water for domestic purposes, it is necessary to consider this natural or normal chlorine, and whenever the chlorine present is in excess of the normal the evidence of past pollution is complete.

It has been found, moreover, that (with the exception of local deposits) the normal chlorine in natural waters is derived from the salt of the ocean, blown over the land by storms, and that it diminishes in amount as the distance from the ocean increases. This decrease is so definite that equal amounts of chlorine are found along lines generally parallel to the seacoast, thus affording a basis for the establishment of isochlors. In Massachusetts and Connecticut these lines have been located, and for several years the information has proved to be of great value to the water-supply interests of those States. The accompanying paper extends this information to the remainder of the New England States and to New York.

Very respectfully,

F. H. NEWELL,
*Chief Engineer.*

Hon. CHARLES D. WALCOTT,
*Director United States Geological Survey.*

# THE NORMAL DISTRIBUTION OF CHLORINE IN THE NATURAL WATERS OF NEW YORK AND NEW ENGLAND.

By Daniel D. Jackson.

## INTRODUCTION.

Chlorine, a constituent of common salt, is present in nearly all natural waters. Its original sources are mineral salt deposits and finely divided salt spray from the sea. This latter is carried with dust particles by the wind and precipitated with the rain. All salt found in waters not coming from these original sources comes from domestic drainage and indicates that the water either is at the present time polluted or was polluted and has since been purified. By a comparison of the salt content of any water under examination with the normal chlorine figure for that region the extent of past or present pollution may be determined.

## PHYSIOLOGICAL FUNCTIONS OF COMMON SALT.

Salt always occurs in drainage from animal sources, because in all animal economy a certain fairly definite amount of common salt is eaten with the food daily and later expelled from the body in practically the same condition in which it was absorbed. That it plays an important rôle in the blood is indicated by the fact that on an average it constitutes about one-half of the total blood ash. It is also found that normal gastric juice can not be formed without the presence of salt, and that in many other secretions of the body its presence is probably a necessity.

## SALT AS AN INDICATION OF POLLUTION.

The amount of salt in a water is a valuable indication of pollution because of the following facts: (1) The animal body expels the same amount of salt that it absorbs; (2) this salt is unchangeable in the soil and is very soluble in water; (3) it must eventually form a part of the drainage and become mixed with the general run-off of the region in which it is expelled. The average amount of salt entering the drainage of any particular district is so constant for each inhabitant that it has been claimed that the number of people living on a drainage area may be determined with a fair degree of accuracy from the average

run-off and the excess of chlorine over the normal. Stearns[a] estimates the chlorine in the run-off of any drainage area not receiving factory waste to be increased about one-tenth of a part per million by every 20 inhabitants per square mile.

## SALT IN THE WATERS OF INLAND STATES.

All salt in natural unpolluted waters farther inland than Ohio comes from mineral deposits. The salt winds from the sea have no effect beyond this State, but unfortunately west of this State a large proportion of the natural waters are more or less affected by the salt deposits. The underground salt seems to spread over a broad area and exerts not only a wide but a variable influence over most of the waters. In these inland States, while the "normal chlorine" would be practically zero the value of the determination of chlorine is in most cases vitiated by the variable quantity of salt from mineral sources. Determinations of chlorine in samples of water taken above and below a city which runs its drainage into the stream examined may give the extent of pollution due to the city sewage, but the waters so far analyzed in the inland States give indications that the question of *normal* chlorine does not to any great extent enter into sanitary problems.

## SALT IN COAST STATE WATERS.

On the other hand, the coast State waters are practically unaffected by this mineral salt, and, while very extensive deposits exist, especially in the State of New York, they are in narrow pockets and exert an influence over a very limited area. Except in these pockets the mineral salt has apparently been washed into the sea.

It is found that in the coast States the salt in the natural waters which comes from original sources is practically all brought in by the sea winds, and that a certain normal amount is present in the waters of each locality.

The difference in the normal amount in different localities is due to variations (1) in distance from the seacoast, (2) in the amount of rainfall, (3) in the rate of evaporation, (4) in the amount of protection from ocean winds, and (5) in the direction of the prevailing winds. In spite of the great variety of causes which affect the normal chlorine in natural waters, the normal for any particular region is surprisingly constant.

The chlorine decreases as waters farther and farther inland are tested, so that by connecting with lines on the map localities having the same normal we find that these lines of equal chlorine (isochlors) follow in a general way the coast lines, and as they extend inland are still more or

[a] Stearns, F. P., Rept. Mass. State board of health, 1890, pt. 1, p. 680.

less parallel to the coast. The distance of these lines from the coast depends chiefly upon the general direction of the wind and the protecting influences of mountains on the coast or of islands near the mainland.

## COLLECTION OF SAMPLES.

In order to obtain the normal chlorine lines for any State it is necessary to first collect a large number of analyses for chlorine in waters taken at different seasons over the entire area to be covered. It is evident that near the seacoast, where the variations in chlorine within a limited area are greatest, the largest number of data must be collected. A large number of samples of water taken from surface and ground sources must be obtained. The pond waters usually give the best results, and careful inspection of the drainage area of such sources gives a good idea of whether or not the water is subject to pollution. Samples for analysis should be chosen as far from human habitation as possible.

## SOLUTIONS REQUIRED FOR CHLORINE DETERMINATIONS.

The following solutions are employed in the analysis of water for chlorine:

*Salt solution.*—A solution of chemically pure fused salt, containing 1 milligram of chlorine in each cubic centimeter is made by dissolving 1.648 grams of the fused sodium chloride in 1 liter of distilled water free from chlorine.

*Silver nitrate solution.*—Two and one-half grams of crystallized silver nitrate are dissolved in 1 liter of distilled water free from chlorine. To this solution water or strong silver nitrate is added until by actual titration 10 c. c. of it are equivalent to 5 c. c. of the standard salt solution. One cubic centimeter of this solution is then equivalent to 0.5 milligram of chlorine.

*Potassium chromate solution.*—An indicator solution is made by dissolving 50 grams of potassium chromate in 1 liter of distilled water and then adding sufficient silver-nitrate solution to precipitate all the chlorine present and turn the precipitate slightly reddish. This is allowed to stand, and (by filtering or decanting) the clear solution is then obtained.

*Emulsion of alumina.*—This is made by dissolving 125 grams of potassium or ammonium alum in 1 liter of water and precipitating the alumina from the boiling solution by ammonia. After precipitation the alumina must be washed free from chlorine, sulphate, and ammonia by successive treatments, settlings, and decantations with cold distilled water.

## METHODS OF PROCEDURE IN THE DETERMINATION OF CHLORINE.

Pour 25 c. c. of the water to be tested into a white porcelain dish. Add about one-half a cubic centimeter of chromate solution and run in standard silver-nitrate solution from a burette until the first faint reddish tint appears. This is more easily noted if, for comparison, a dish containing the same amount of water and chromate is kept beside the dish in which the test is made.

If one or more cubic centimeters of silver nitrate are necessary to reach an end point, the test may be made without evaporation, but if less is required, then evaporate 250 c. c. to 25 c. c. volume before making the test. It may at times be necessary to evaporate more than this if the chlorine present is very close to zero in amount.

It is best to always titrate with 25 c. c. of the water. In this case 0.1 c. c. is subtracted from the results as an indicator error. If more than this amount is used in titration, subtract 0.1 c. c. for each 25 c. c. of the volume of water titrated.

If 250 c. c. of water are taken, the number of cubic centimeters of silver nitrate solution used to obtain an end point minus 0.1 c. c. multiplied by 2 gives the chlorine in parts per million.

Example: 250 c. c. are evaporated to a volume of 25 c. c. and chromate solution added. In the titration 3.5 c. c. of silver nitrate are used. Then $(3.5-0.1)\times 2=6.8$. The water then contains 6.8 parts per million of chlorine.

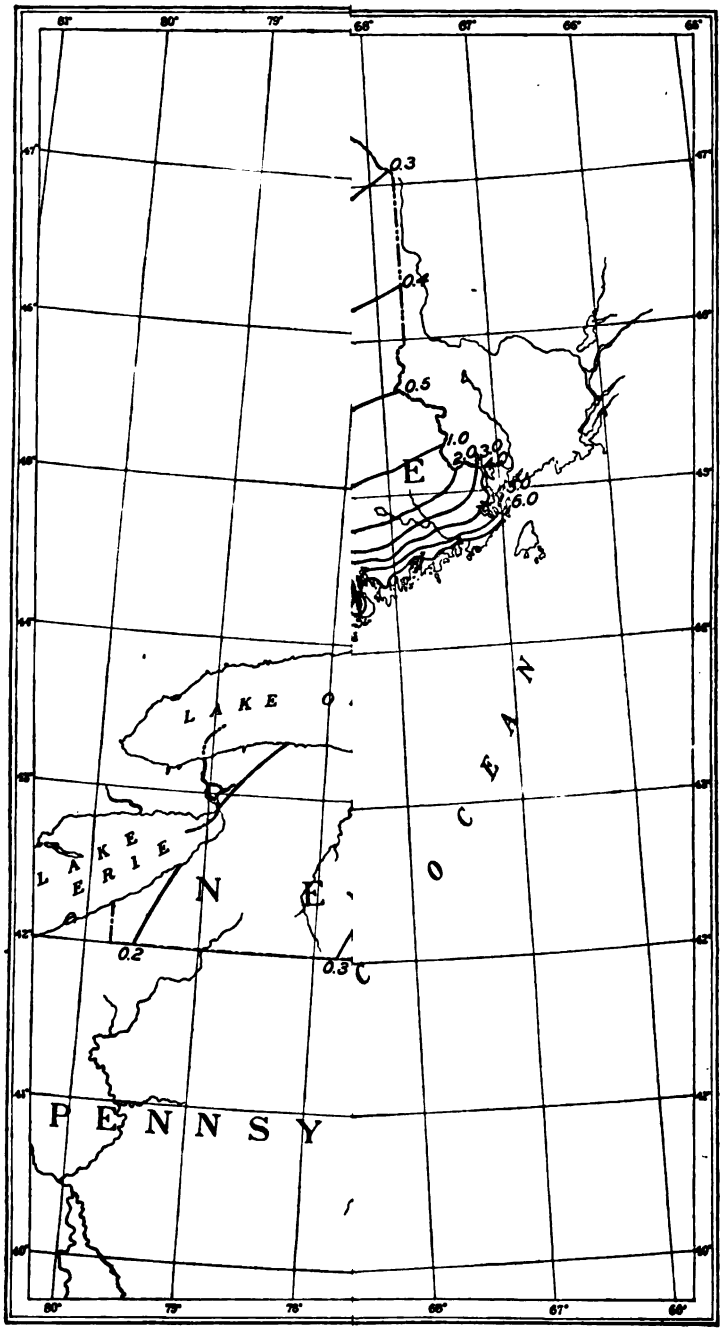
If the sample is highly colored and very turbid, it may be necessary to clarify it by treating it with an emulsion of alumina. This is best accomplished by bringing the water just to the boiling point, and then adding alumina and shaking the emulsion. In a few minutes the clarified water may be decanted. This is allowed to cool and the required amount is measured out for titration.

## OBSERVATIONS ON THE USE OF THE NORMAL CHLORINE MAP.

Having drawn a map of this character for any coast State we are then able to estimate the pollution in any natural water by the amount of chlorine present over the normal. In some instances it is first necessary to ascertain that the chlorine is not from mineral sources.

It will be seen that the normal chlorine lines are of great practical value both to the chemist and to the engineer, as they give an index from which may be estimated the sanitary quality of most waters analyzed within the coast States. The chlorine also furnishes information as to the source of deep-seated springs or artesian wells.

While this chlorine in the general run-off is in direct proportion to the population on a drainage area, provided none of the sewage is carried outside of that area, yet waters in this region may have been puri-


0.3
0.4
0.5
1.0
2.0
3.0
4.0
5.0
6.0
E
LAKE ONTARIO
LAKE ERIE
N E
O C E A N
0.2
0.3
PENNSY

*Chlorine determinations for Maine.*

[Parts per million.]

| Source. | Chlorine. |
|---|---|
| Androscoggin County: | |
| Auburn, Lake Auburn | 2.0 |
| Curtis Corner, spring | 2.0 |
| Lewiston, spring | 2.0 |
| well | 2.0 |
| Lisbon, spring | 2.5 |
| Livermore Falls, spring | .8 |
| Mechanic Falls, spring | 1.5 |
| water supply | 2.0 |
| Sabattus, spring | 2.0 |
| Turner, well | 2.0 |
| West Minot, spring | 2.0 |
| Aroostook County: | |
| Caribou, well | .3 |
| Fort Fairfield, spring | .3 |
| Fort Kent, spring | .3 |
| Houlton, spring | .4 |
| Presque Isle, brook | .3 |
| Cumberland County: | |
| Ash Cove, spring | 6.0 |
| Brunswick, spring | 2.8 |
| water supply | 4.0 |
| Deering, spring | 4.0 |
| East Baldwin, well | 2.0 |
| Gray, spring | 2.5 |
| Growstown, spring | 5.2 |
| North Raymond, spring | 2.0 |
| Portland, spring | 6.0 |
| Pownal, spring | 6.0 |
| Saccarappa, well | 5.0 |
| Scarboro, spring | 6.0 |
| Sebago, lake | 2.0 |
| well | 2.0 |
| Walnut Hill, well | 5.0 |
| West Baldwin, spring | 1.5 |
| Westbrook, spring | 4.0 |
| Yarmouth, spring | 6.0 |
| Yarmouthville, spring | 5.0 |
| Franklin County: | |
| Avon, pond | .8 |
| Hancock County: | |
| Bar Harbor, Eagle Lake | 5.0 |
| Brooklin, spring | 8.0 |
| well | 8.6 |
| Brooksville, spring | 6.0 |
| Bucksport, well | 5.0 |
| Castine, spring | 5.0 |
| Lemoine, spring | 5.0 |
| Sedgwick, Black Pond | 5.8 |
| spring | 6.8 |
| spring | 6.4 |
| Upper Pond | 6.5 |
| Kennebec County: | |
| Augusta, well | 2.0 |
| Gardiner, spring | 3.0 |
| Manchester, well | 1.5 |
| Monmouth, spring | 2.0 |
| Riverside, spring | 2.0 |
| Waterville, China Lake | 1.5 |
| Messalonskie Lake | 1.2 |
| Messalonskie River | 1.2 |
| Tobey Stream | 1.2 |
| West Sidney, spring | 2.0 |
| Winslow, spring | 2.0 |
| Winthrop, well | 2.0 |
| well | 2.0 |
| Knox County: | |
| Camden, spring | 4.0 |
| Rockland, water supply | 3.7 |
| Thomasville, water supply | 6.0 |
| Union, spring | 2.5 |
| Warren, spring | 4.0 |
| Washington, spring | 2.5 |
| Lincoln County: | |
| Jefferson, stream | 3.0 |
| Waldoboro, well | 4.0 |
| Oxford County: | |
| Andover, spring | .5 |
| Canton, well | 1.0 |
| Dixfield, small brook | .8 |

*Chlorine determinations for Maine*—Continued.

[Parts per million.]

| Source. | Chlorine. |
|---|---|
| Oxford County—Continued. | |
| Fryeburg, well | 1.0 |
| Gilead, reservoir | .6 |
| Middle dam, Richardson Lake | .6 |
| Upper dam, spring | .5 |
| Welchville, well | 1.0 |
| West Bethel, spring | .8 |
| Penobscot County: | |
| Bangor, spring | 1.5 |
| Dexter, well | .7 |
| Hampden, well | 2.0 |
| Old Town, spring | 1.0 |
| Piscataquis County: | |
| Greenville, spring | .5 |
| Guilford, spring | .5 |
| Sagadahoc County: | |
| Bath, lake | 4.0 |
| spring | 6.0 |
| water supply | 4.0 |
| Bowdoinham, spring | 4.0 |
| Richmond, water supply | 2.5 |
| Somerset County: | |
| Pittsfield, spring | 1.0 |
| The Forks, spring | .4 |
| Waldo County: | |
| Brooks, well | 3.0 |
| Stockton Springs | 6.0 |
| Swanville, well | 5.0 |
| Waldo County—Continued. | |
| Unity, reservoir | 1.5 |
| Winterport, well | 2.0 |
| Washington County: | |
| Baring, Spragues Falls | 2.3 |
| Calais, spring | 4.0 |
| Cherryfield, spring | 4.0 |
| Eastport, Chadburn dam | 2.4 |
| Perry dam | 3.2 |
| water supply | 3.1 |
| East Machias, lake | 4.0 |
| Edmonds, spring | 4.0 |
| Harrington, spring | 6.0 |
| Machias, spring | 6.0 |
| York County: | |
| Alfred, well | 2.5 |
| Cape Elizabeth, well | 9.0 |
| Cornish, spring | 1.5 |
| Eliot, spring | 4.0 |
| Hollis, well | 3.0 |
| Kennebunk, spring | 5.0 |
| well | 6.0 |
| Lebanon, well | 4.0 |
| Limington, spring | 2.0 |
| Lyman, spring | 3.0 |
| Old Orchard, spring | 6.0 |
| Sandford, spring | 2.7 |
| well | 3.0 |
| South Berwick, spring | 3.5 |
| Springfield, well | 4.0 |

## THE ISOCHLORS OF NEW HAMPSHIRE.

The New Hampshire isochlors (Pl. III) were drawn from observations obtained by Mr. H. E. Barnard, chemist, New Hampshire State board of health, and from the work of Mr. M. O. Leighton and the author.

The outlines follow the seacoast in a general way, but the inland lines (0.4 and 0.5 part per million) are deflected to some extent toward the coast by the influence of the White Mountains. The following is

an extract from Mr. Barnard's letter on the normal chlorine of New Hampshire:

I am inclosing the results of the chlorine determination of 570 waters, collected from 145 different towns. About 200 of these determinations, representing waters from the southeastern part of the State, near the coast, were made on samples collected expressly for the chlorine work and are from supplies of known purity. The remainder of the examinations were made in the course of our regular work on sanitary water analyses, and the results are selected from over 1,800 analyses. We feel confident that they represent normal chlorines, as they are mainly spring supplies. The chlorine factor was not accepted as normal, however, until complete sanitary analyses had proved the supply to be entirely free from contamination.

Some few results represent town supplies, and others are obtained from analyses of small mountain streams. The incorporation of the results of analyses of river water has been avoided because the chlorine content of an unpolluted river water is frequently less than that of the town through which it flows, due, of course, to the fact that the river is fed by streams and ponds along the mountains where the normal chlorine is low.

The chlorine content of waters along the coast has been determined carefully and is found to diminish so rapidly that 5 miles will frequently change the isochlor 10 parts per million. This is, of course, true only near the coast. It may be argued that determinations of chlorine in water located directly on the coast have little significance because of the liability of change of chlorine content when heavy storms sweep in off the sea. I have found that duplicate analyses, made at different seasons, showed differences so slight that they were well within the limit of error. Referring to the chlorine map you have drafted, I am surprised that our isochlors agree so closely.

The following list gives the observations which have had a bearing upon the determination of normal chlorine lines in the State of New Hampshire:

*Chlorine determinations for New Hampshire.*

[Parts per million.]

| Source. | Samples. | Chlorine. | Source. | Samples. | Chlorine. |
|---|---|---|---|---|---|
| Belknap County: | | | Carroll Co.—Cont'd. | | |
| Belmont | 5 | 0.73 | Lower Bartlett | ..... | 0.5 |
| Center Harbor | 1 | .9 | Moultonboro | ..... | .9 |
| Gilmantown | 1 | .75 | Mount Pleasant | 2 | .66 |
| Laconia | 4 | 1.18 | Ossipee | 2 | .87 |
| Meredith | 1 | 1.0 | Snowville | 2 | .87 |
| New Hampton | 8 | .79 | Tamworth | 2 | 1.0 |
| Tilton | 9 | 1.0 | Wakefield | 1 | 2.5 |
| Carroll County: | | | Wolfboro | 3 | .73 |
| Bartlett | 1 | .75 | Cheshire County: | | |
| Do | ..... | .7 | Chesham | 3 | .72 |
| Conway | 3 | .58 | Dublin | 5 | .93 |
| Eaton | 1 | .75 | Fitzwilliam | 1 | 1.0 |
| Freedom | 1 | .75 | Do | ..... | .7 |
| Intervale | 1 | .5 | Harrisville | 3 | .75 |

NORMONT AND NEW HAMPSHIRE.

*Chlorine determinations for New Hampshire*—Continued.

[Parts per million.]

| Source. | Samples. | Chlorine. |
|---|---|---|
| Cheshire Co.—Cont'd. | | |
| Jaffrey | | 0.8 |
| Jaffrey, East | 4 | .87 |
| Keene | 7 | .85 |
| Do | | .7 |
| Marlboro | 2 | .88 |
| Marlow | 1 | .5 |
| Monadnock | 1 | 1.0 |
| Nelson | 3 | 1.01 |
| Troy | 1 | 1.0 |
| Walpole | 2 | .62 |
| Winchester | 1 | .92 |
| Coos County: | | |
| Berlin | 3 | .75 |
| Colebrook | 1 | .5 |
| Dummer | | .4 |
| Erroll | | .3 |
| Gorham | 2 | .75 |
| Groveton | | .5 |
| Jefferson | 1 | .39 |
| Lancaster | 2 | .5 |
| Stratford | 2 | .5 |
| Whitefield | 3 | .43 |
| Grafton County: | | |
| Alexandria | 1 | .60 |
| Ashland | | .7 |
| Bethlehem | 7 | .55 |
| Do | | .6 |
| Bridgewater | 1 | .75 |
| Bristol | 4 | .77 |
| Do | | .6 |
| Campton | 11 | .65 |
| Do | | .6 |
| Canaan | 12 | .64 |
| Do | | .7 |
| Franconia | 1 | .5 |
| Grafton | 2 | .74 |
| Hanover | 8 | .78 |
| Do | | .5 |
| Haverhill | 4 | .6 |
| Grafton Co.—Cont'd. | | |
| Lincoln | 3 | 0.46 |
| Lisbon | 4 | .75 |
| Littleton | 15 | .74 |
| Lyme | 3 | .78 |
| Orford | | .5 |
| Do | 3 | .82 |
| Piermont | 3 | .67 |
| Pike | 1 | .49 |
| Plymouth | | .7 |
| Do | 10 | .89 |
| Warren | 7 | .77 |
| Woodsville | 3 | .63 |
| Hillsboro County: | | |
| Amherst | 2 | 1.0 |
| Antrim | 7 | 1.01 |
| Do | | .9 |
| Bennington | 3 | .67 |
| Brookline | 3 | .14 |
| Deering | 1 | .60 |
| Francestown | 2 | 1.0 |
| Goffstown | 6 | 1.5 |
| Greenfield | 8 | .79 |
| Greenville | | 1.2 |
| Hillsboro | 2 | .65 |
| Hudson | 6 | 1.34 |
| Manchester | 16 | 1.34 |
| Mason | 1 | 1.0 |
| Mount Vernon | 3 | 1.08 |
| Nashua | 3 | 1.5 |
| New Ipswich | 5 | 1.1 |
| Peterboro | 23 | .97 |
| Weare | 5 | 1.23 |
| Wilton | 6 | 1.13 |
| Merrimack County: | | |
| Allenstown | | 1.5 |
| Andover | 2 | .82 |
| Boscawen | 3 | .88 |
| Bradford | 4 | .89 |
| Chichester | 1 | 1.0 |

*Chlorine determinations for New Hampshire*—Continued.

[Parts per million.]

| Source. | Samples. | Chlorine. | Source. | Samples. | Chlorine. |
|---|---|---|---|---|---|
| Merrimack Co.—Con. | | | Rockingham County—Continued. | | |
| Concord | 21 | 1.28 | Sandown | 2 | 1.5 |
| Do | | 1.1 | Seabrook | 3 | 2.20 |
| Danbury | 2 | .95 | South Hampton | 6 | 4.3 |
| Epsom | 14 | 2.06 | Stratham | 2 | 6.7 |
| Franklin | 16 | 1.03 | Strafford County: | | |
| Henniker | 2 | .73 | Barrington | 5 | 2.30 |
| Hill | 2 | 1.0 | Dover | 13 | 3.19 |
| Hopkinton | 3 | 1.03 | Durham | 1 | 3.75 |
| Loudon | 1 | .93 | Farmington | 1 | 2.00 |
| Pembroke | 2 | 1.5 | Gonic | 2 | 1.68 |
| Penacook | 1 | 1.1 | Millton | 1 | 1.75 |
| Pittsfield | 3 | 1.5 | Rochester | 3 | 2.5 |
| Salisbury | 3 | 1.0 | Do | | 1.5 |
| Suncook | 2 | 1.5 | Salmon Falls | 2 | 2.83 |
| Sutton | 5 | .85 | Summersworth | 6 | 2.65 |
| Warner | 12 | .89 | Sullivan County: | | |
| Rockingham County: | | | Charlestown | 3 | .87 |
| Atkinson | 5 | 3.2 | Claremont | 9 | .82 |
| Auburn | 5 | 1.6 | Do | | .7 |
| Exeter | | 3.7 | Cornish | 3 | .90 |
| Do | 2 | 3.25 | Goshen | 1 | .6 |
| Hampton | | 6.0 | Meriden | 1 | .65 |
| Hampstead | 6 | 2.59 | Newport | 3 | .83 |
| Londonderry | 5 | 1.75 | Plainfield | | .6 |
| Newmarket | 4 | 3.2 | Springfield | 1 | 1.0 |
| Newton | 6 | 3.60 | Sunapee | 11 | .74 |
| Portsmouth | 6 | 4.0 | Unity | 1 | .6 |
| Salem | | 2.1 | Washington | 3 | .6 |
| Salem Depot | 8 | 2.45 | | | |

## THE ISOCHLORS OF VERMONT.

The Vermont isochlors (Pl. III) are drawn from data obtained from Mr. C. P. Moat, chemist, Vermont State board of health. It will be seen that the isochlors are modified to a considerable extent by the Green Mountains, as well as by the White Mountains in New Hampshire. The following figures, supplied by Mr. Moat, are not only interesting as determinations of normal waters but also as showing the range of variation in these waters:

*Chlorine determinations for Vermont.*

[Parts per million.]

| Source. | Samples. | Chlorine. |
|---|---|---|
| Addison County: | | |
| Bristol | 12 | 0.47 |
| Lincoln | 1 | .3 |
| Monkton | 2 | .6 |
| Middlebury | 7 | .5 |
| Shoreham | 1 | .3 |
| Vergennes | 2 | .5 |
| Whiting | 2 | .45 |
| Bennington County: | | |
| Arlington | 6 | .5 |
| Bennington | 7 | .5 |
| Dorset | 3 | .5 |
| Manchester | 11 | .5 |
| Readsboro | 6 | .52 |
| South Shaftsbury | 3 | .5 |
| Stamford | 1 | .6 |
| Caledonia County: | | |
| Barnet | 1 | .5 |
| Hardwick | 3 | .57 |
| Lyndonville | 7 | .44 |
| Lyndon | 2 | .5 |
| St. Johnsbury | 4 | .53 |
| West Burke | 3 | .33 |
| Chittenden County: | | |
| Charlotte | 1 | .5 |
| Essex Junction | 2 | .6 |
| Jericho | 1 | .4 |
| South Burlington | 1 | .5 |
| Winooski | 1 | .6 |
| Essex County: | | |
| Brighton | 4 | .4 |
| Canaan | 5 | .52 |
| Island Pond | 1 | .3 |
| Franklin County: | | |
| Enosburg | 1 | .6 |
| Fairfield | 1 | .6 |
| Fairfax | 1 | .3 |
| Montgomery | 2 | .55 |
| Richford | 4 | .6 |
| St. Albans | 2 | .55 |
| Swanton | 5 | .52 |
| Lamoille County: | | |
| Cambridge | 6 | 0.47 |
| Elmore | 2 | .45 |
| Hyde Park | 3 | .57 |
| Johnson | 5 | .38 |
| Morrisville | 2 | .6 |
| Orange County: | | |
| Bradford | 4 | .6 |
| Corinth | 2 | .6 |
| Newbury | 2 | .65 |
| Randolph | 5 | .56 |
| Strafford | 2 | .45 |
| Rutland County: | | |
| Mount Tabor | 1 | .5 |
| Pittsford | 5 | .42 |
| Poultney | 4 | .42 |
| Proctor | 6 | .55 |
| Rutland | 7 | .47 |
| Rutland Center | 4 | .45 |
| Sudbury | 1 | .4 |
| Wallingford | 1 | .5 |
| Washington County: | | |
| Barre | 4 | .5 |
| Berlin | 2 | .4 |
| Cabot | 1 | .4 |
| Duxbury | 2 | .6 |
| Marshfield | 2 | .45 |
| Middlesex | 4 | .4 |
| Montpelier | 9 | .51 |
| Northfield | 9 | .49 |
| Waterbury | 6 | .53 |
| Windham County: | | |
| Bellows Falls | 1 | .6 |
| Brattleboro | 1 | .6 |
| Saxtons River | 2 | .55 |
| Stratton | 1 | .6 |
| Townsend | 1 | .6 |
| Wilmington | 3 | .43 |
| Windsor County: | | |
| Barnard | 4 | .5 |
| Bethel | 1 | .4 |

*Chlorine determinations for Vermont*—Continued.

[Parts per million.]

| Source. | Samples. | Chlorine. | Source. | Samples. | Chlorine. |
|---|---|---|---|---|---|
| Windsor Co.—Cont'd. | | | Windsor Co.—Cont'd. | | |
| Chester | 4 | 0.55 | Rochester | 4 | 0.4 |
| Hartford | 5 | .56 | Royalton | 2 | .4 |
| Norwich | 7 | .47 | Springfield | 9 | .52 |
| Pomfret | 1 | .7 | Windsor | 4 | .5 |
| Plymouth | 1 | .6 | Woodstock | 5 | .4 |

Besides these observations the following may also be considered in estimating the isochlors for this State:

*Chlorine determinations for Vermont—Additional list.*

[Parts per million.]

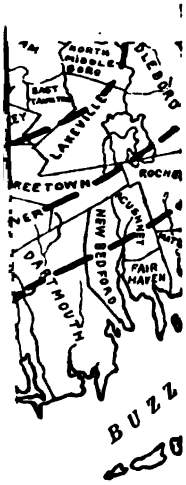
| Source. | Chlorine. | Source. | Chlorine. |
|---|---|---|---|
| Arlington, spring | 0.5 | Manchester, water supply | 0.4 |
| Barnet, water supply | .5 | Middlesex, spring | .4 |
| Bennington, spring | .4 | Monkton, water supply | .5 |
| Cambridge, spring | .4 | Morrisville, spring | .5 |
| East Burke, spring | .5 | North Troy, spring | .5 |
| Enosburg Falls, spring | .4 | Readsboro, water supply | .5 |
| Georgeville, spring just above | | St. Johnsbury, Stiles Pond | .5 |
| State line | .4 | Waltham, spring | .4 |
| Lincoln, spring | .5 | | |

## THE ISOCHLORS OF MASSACHUSETTS.

The Massachusetts isochlors (Pl. IV) are practically the same as those published by the Massachusetts State board of health in their report of 1890. In minor respects these lines have been modified to conform with the work in adjoining States. It is only in the isochlor of 1 part per million that any material change has been made. This line was modified to agree with the work in Connecticut and New York.

The northeast winds sweeping across this State have a tendency to drive the chlorine far inland, and it will be seen that most of the lines are farther from the coast than would be expected, and that this effect is greatest in the most exposed areas. In the western part of the State this is, to some extent, counteracted by the Holyoke Range and the Berkshire Hills.

The following average observations have influenced the establishment of the position of the Massachusetts isochlors:


NORTH MIDDLEBORO
EAST TAUNTON
LAKEVILLE
ROCHE
NEW BEDFORD
DARTMOUTH
FAIR HAVEN
BUZZ

1

CHUSETTS,

*Chlorine determinations for Massachusetts.*

[Parts per million.]

| Source. | Chlorine. |
|---|---|
| Berkshire County: | |
| Cheshire, reservoir | 0.6 |
| Dalton, Egypt Brook | .7 |
| lower reservoir | .7 |
| Great Barrington, Green River | .9 |
| Hinsdale, east branch Housatonic River | .8 |
| storage reservoir | .7 |
| Lee, lower reservoir | .7 |
| Lenox, reservoir | .7 |
| North Adams, Notch Lake | .6 |
| Pittsfield, Pontoosuc Lake | .4 |
| Millbrook reservoir | .9 |
| Sackett Brook | .8 |
| Sheffield, spring | .7 |
| Stockbridge, Lake Averie | .7 |
| Williamstown, Cold Spring | .6 |
| Sherman Spring | .5 |
| Bristol County: | |
| Fall River, Watuppa Lake | 5.2 |
| New Bedford, Acushnet reservoir | 5.3 |
| Essex County: | |
| Andover, spring | 2.4 |
| Danvers, Middleton Pond | 3.5 |
| Haverhill, Crystal Lake | 2.7 |
| Ipswich, storage reservoir | 5.3 |
| Methuen, spring | 2.0 |
| Franklin County: | |
| Conway, brook | .7 |
| Deerfield, brook | .6 |
| Greenfield, Glen Brook | 1.1 |
| Montague, Lake Pleasant | 1.0 |
| Northfield, reservoir | .7 |
| Orange, reservoir | .9 |
| Whateley, West Brook | .9 |
| Hampden County: | |
| Chester, Austen Brook reservoir | .6 |
| Chicopee, Cooley Brook reservoir | 1.1 |
| Granville, middle branch Westfield River | 1.2 |
| Ludlow, Chapin Pond | 1.0 |
| Hampden County—Continued. | |
| Monson, well | 1.2 |
| Russell, middle branch Westfield River | .7 |
| Springfield, Ludlow reservoir | 1.2 |
| Hampshire County: | |
| Huntington, east branch Westfield River | 1.0 |
| middle branch Westfield River | .9 |
| Middlesex County: | |
| Ashland, Basin No. 4 | 2.3 |
| Concord, Sandy Pond | 2.5 |
| Framingham, reservoir | 2.3 |
| Hudson, Gates Pond | 2.0 |
| Pepperell, spring | 1.5 |
| Sudbury, reservoir | 2.2 |
| Wayland, Snake Brook | 2.3 |
| Nantucket County: | |
| Nantucket, Wannacomet Pond | 22.6 |
| Plymouth County: | |
| Hingham, Accord Pond | 6.0 |
| Lakeville, Long Pond | 4.5 |
| Plymouth, Little South Pond | 6.2 |
| Worcester County: | |
| Ashburnham, storage reservoir | 1.3 |
| Berlin, Fosgate Brook | 1.9 |
| Clinton, Lyndes Brook | 1.6 |
| Holden, Tatnuck Brook | 1.2 |
| Leicester, storage reservoir | 1.2 |
| Leominster, Haynes reservoir | 1.2 |
| North Brookfield, Doan Pond | 1.2 |
| Rutland, Musquahog Lake | 1.4 |
| Southbridge, reservoir | 1.3 |
| Spencer, Shaw Pond | 1.4 |
| Sterling, Stillwater River | 1.6 |
| Worcester, Bottomly Pond | 1.5 |
| Kent reservoir | 1.5 |
| Tatnuck Brook reservoir | 1.3 |

## THE ISOCHLORS OF RHODE ISLAND.

The lines of equal chlorine for Rhode Island (Pl. IV) are drawn from data furnished by Dr. Gardner T. Swarts, secretary of the Rhode Island State board of health. Observations made in Massachusetts and Connecticut were also of great assistance in defining these lines. The following analyses in Rhode Island have influenced the determination of their position:

*Chlorine determinations for Rhode Island.*

[Parts per million.]

| Source. | Chlorine. | Source. | Chlorine. |
|---|---|---|---|
| Kent County: | | Providence County—Continued. | |
| Washington, Carr's pond | 2.9 | Harrisville, Wallum Pond | 1.8 |
| East Greenwich | 4.0 | Foster, spring | 2.1 |
| Newport County: | | Diamond Hill, well | 2.9 |
| Block Island, Sand's pond | 30.8 | Washington County: | |
| Providence County: | | Wakefield, spring | 5.4 |
| Pawtuxet Valley, reservoir | 3.4 | Rocky Brook | 5.8 |
| Pawtucket supply, Abbott Run | 3.2 | West Kingston, Barber's pond | 3.2 |
| Woonsocket, reservoir No. 3 | 2.2 | 100-acre Pond | 3.6 |

## THE ISOCHLORS OF CONNECTICUT.

The normal chlorine lines in Connecticut (Pl. IV) were established by Dr. Herbert E. Smith, chemist, Connecticut State board of health, and Dr. Frederick S. Hollis, from whose article in the report of the Connecticut State board of health for 1902, together with their observations on normal waters of the State, the extract quoted below is taken.

Observations since obtained from Doctor Smith give data for adding the 4, 5, and 6 lines to the map. The strong protecting influence of Long Island cuts these lines off on the western coast in a very peculiar manner.

### NORMAL DISTRIBUTION OF CHLORINE IN CONNECTICUT.

In the report of the Connecticut State board of health for 1895 a chlorine map of the State was published, which was based on averages of chlorine determinations from 38 sources. The origin of chlorine in natural waters and the value of an accurate knowledge of the normal chlorine of a district, any excess above which is an important factor in establishing the degree of contamination, were fully discussed.

During the seven years that have elapsed since the publication of the map many of the sources used in the construction of the isochlorine lines have been reexamined, and many new sources have been examined by making monthly or bimonthly analyses during one or more years. Much information has been gained also from

the large number of analyses of individual samples from different parts of the State, as in the systematic examination of spring waters. The averages of the chlorine determinations from those sources which appear to be free or practically free from contamination are used in the construction of the new map. The 71 sources are divided, according to the number of analyses, into three groups and entered alphabetically. * * * Each average is entered on the map, and isochlorine lines are drawn indicating the center of the comparatively limited zones in which the chlorine agrees with that of the given chlorine line.

Considerable difficulty was found, as in the case of the earlier map, in locating the lines in the eastern part of the State, where there are very few public supplies and from which section but few determinations have been made. Samples were analyzed monthly from April to September, 1902, from Wyassup Pond, in North Stonington; Beachdale Pond, in Voluntown; Moosup Pond, in Plainfield (the drainage area of which extends into Killingly; the Danielson reservoirs, in Killingly, and Crystal Pond, between Eastford and Woodstock. These, with previously collected data, probably locate the lines with a fair degree of accuracy, and have resulted in lowering the 3 and 2.5 lines considerably and in raising the 2 and 1.5 lines, as compared with the earlier map.

AVERAGES OF CHLORINE DETERMINATIONS UPON WHICH THE MAP IS BASED.

[Parts per million.]

SOURCES FROM WHICH TWELVE OR MORE DETERMINATIONS HAVE BEEN MADE.

| | | | | | |
|---|---|---|---|---|---|
| Ansonia | 2.8 | Kent | 1.6 | Ridgefield | 2.2 |
| Berlin | 1.9 | Killingly | 2.3 | Seymour | 2.3 |
| Bethany | 2.4 | Killingworth | 2.9 | Southington | 1.7 |
| Bethel | 1.9 | Manchester | 1.8 | Do | 1.9 |
| Branford | 4.5 | Meriden | 1.9 | South Manchester | 1.8 |
| Bridgeport | 3.7 | Middletown | 2.5 | Stamford | 2.3 |
| Bristol | 1.5 | Morris | 1.6 | Stonington | 5.1 |
| Chaplin | 1.9 | Naugatuck | 2.0 | Thomaston | 1.6 |
| Danbury | 2.3 | Naugatuck River | 1.6 | Watertown | 1.7 |
| Durham | 2.7 | New Canaan | 2.7 | Waterford | 3.3 |
| East Haven | 4.1 | New Milford | 1.8 | West Hartford | 1.5 |
| Easton | 2.9 | North Canaan | 1.2 | West Haven | 6.0 |
| Farmington | 1.8 | Norwich | 2.6 | Winchester | 1.3 |
| Goshen | 1.5 | Orange | 2.3 | Wolcott | 1.9 |
| Greenwich | 3.0 | Rockville | 1.6 | Do | 2.0 |
| Hamden | 2.4 | | | | |

SOURCES FROM WHICH SIX DETERMINATIONS HAVE BEEN MADE.

| | | | | | |
|---|---|---|---|---|---|
| Chester | 3.0 | Oxford | 1.7 | Union | 1.4 |
| Eastford | 1.8 | Do | 2.2 | Voluntown | 2.7 |
| Moosup | 2.2 | Stafford Springs | 1.6 | West Cornwall | 1.1 |
| North Stonington | 3.1 | Thomaston | 1.6 | Do | 1.3 |

SOURCES FROM WHICH THREE DETERMINATIONS HAVE BEEN MADE.

| | | | | | |
|---|---|---|---|---|---|
| East Granby | 1.6 | New Hartford | 1.3 | Southington | 1.9 |
| East Hartford | 2.0 | North Canaan | 1.1 | Simsbury | 1.8 |
| Farmington | 1.9 | Portland | 2.4 | Westbrook | 6.7 |
| Griswold | 2.3 | Plymouth | 1.9 | Windsor Locks | 1.5 |
| Hebron | 2.6 | Salisbury | 0.9 | Woodbury | 1.9 |
| New Canaan | 2.7 | Shelton | 3.1 | | |

*Chlorine determinations for Connecticut.*

[Parts per million.]

| Source. | Number of samples. | Average. | Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ansonia [a] | 12 | 2.8 | 1897 | 3.40 | 3.25 | 2.80 | 2.75 | 2.64 | 2.45 | 3.20 | 2.30 | 2.30 | 2.65 | 3.00 | 2.90 |
| Berlin, Kenmere reservoir (Meriden supply) | 12 | 1.9 | 1899 | 1.70 | 2.40 | 1.90 | 1.30 | 1.70 | 1.60 | 1.90 | 1.70 | 2.00 | 1.60 | 2.40 | 2.70 |
| Bethany, Dawson reservoir system [b] | 40 | 2.4 | 1894 | 2.95 | 3.32 | 3.06 | 2.98 | 2.78 | 2.34 | 2.24 | 2.36 | 2.76 | 2.85 | 3.07 | 2.95 |
| | | | 1897 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2.40 | ..... | ..... | 3.10 |
| | | | 1898 | ..... | ..... | 1.80 | ..... | ..... | 1.90 | ..... | ..... | 1.90 | ..... | ..... | 1.90 |
| | | | 1899 | ..... | ..... | 1.60 | ..... | ..... | 1.80 | ..... | ..... | 1.80 | ..... | ..... | 2.90 |
| | | | 1900 | ..... | ..... | 2.40 | ..... | ..... | 2.00 | ..... | ..... | 1.86 | ..... | ..... | 2.60 |
| | | | 1901 | 2.76 | 2.70 | 2.30 | 2.00 | 2.06 | 1.80 | 1.80 | 1.46 | 2.02 | 2.60 | 2.50 | 2.44 |
| | | | 1902 | 2.50 | 2.60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Bethel, storage res. | 12 | 1.9 | 1897 | 2.50 | 2.40 | 1.90 | 1.80 | 1.80 | 1.80 | 1.90 | 1.70 | 1.60 | 1.80 | 2.25 | 2.35 |
| Branford | 12 | 4.5 | 1900 | 4.60 | 4.00 | 3.50 | 6.30 | 4.40 | 4.50 | 3.90 | 4.62 | 4.10 | 4.34 | 4.70 | 4.97 |
| Bridgeport (Island Brook supply) | 12 | 3.7 | 1896 | 3.90 | 3.50 | 3.70 | 3.70 | 3.50 | 3.15 | 3.20 | 3.70 | 3.90 | 3.50 | 4.20 | 4.70 |
| Bristol, storage res. and Poland River | 24 | 1.5 | 1895 | 1.9 | 1.9 | 1.8 | 1.2 | 1.4 | 1.5 | 1.3 | 1.4 | 1.3 | 1.6 | 1.7 | 1.4 |
| | | | 1901 | 2.06 | 1.60 | 1.76 | 1.50 | 1.10 | 1.06 | 1.14 | 1.34 | 1.00 | 1.50 | 1.60 | 1.70 |
| Chaplin, Natchaug River (Willimantic supply) | 35 | 1.9 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.8 | 2.3 | 2.5 | 2.3 | 1.8 |
| | | | 1890 | 1.8 | 2.1 | 1.8 | 1.5 | 1.6 | 1.4 | 1.8 | 2.1 | 2.0 | 2.3 | 1.8 | 2.4 |
| | | | 1891 | 2.0 | 1.5 | 1.3 | 1.8 | 1.7 | 1.3 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1899 | 1.6 | 2.10 | 1.10 | 1.60 | 1.70 | 1.20 | 1.60 | 1.90 | 2.10 | 2.70 | 3.70 | 2.70 |
| Chester, Watrous Pond [c] | 6 | 3.0 | 1895 | ..... | ..... | ..... | 2.9 | 2.8 | 2.9 | 2.8 | 3.1 | ..... | 3.7 | ..... | ..... |
| Danbury (Kohanza supply) | 12 | 2.5 | 1896 | ..... | 2.20 | ..... | 3.20 | ..... | 2.25 | ..... | 3.30 | ..... | 2.20 | ..... | 2.30 |
| | | | 1900 | 3.10 | ..... | 1.70 | ..... | 1.80 | ..... | 2.30 | ..... | 2.26 | ..... | 3.46 | ..... |
| East Lake and Padanaram reservoir | 12 | 2.1 | 1896 | ..... | 2.20 | ..... | 2.25 | ..... | 3.30 | ..... | 2.50 | ..... | 1.90 | ..... | 1.90 |
| | | | 1900 | 2.60 | ..... | 1.90 | ..... | 1.90 | ..... | 1.90 | ..... | 1.38 | ..... | 2.05 | ..... |
| Durham, Lake Pistepaug [d] | 12 | 2.6 | 1895 | 3.4 | 2.7 | 2.9 | 2.7 | 2.5 | 2.6 | 2.5 | 2.4 | 2.5 | 2.8 | 2.6 | 2.5 |
| Eastford, Crystal Pond [e] | 6 | 1.8 | 1902 | ..... | ..... | ..... | 1.94 | 1.84 | 1.74 | 1.60 | 1.80 | ..... | 1.66 | ..... | ..... |
| East Granby [f] | 5 | 1.6 | 1898 | ..... | ..... | ..... | ..... | 1.6 | 1.6 | 1.4 | ..... | 1.5<br>1.7 | ..... | ..... | ..... |
| East Hartford | 3 | 2.0 | 1897 | ..... | 1.90 | ..... | ..... | ..... | 2.00 | ..... | ..... | ..... | ..... | 2.20 | ..... |
| East Haven, Lake Saltonstall (New Haven supply) | 36 | 4.1 | 1890 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 3.6 | 3.7 | 4.1 | 3.9 | 3.7 |
| | | | 1891 | 3.6 | 3.5 | 3.5 | 3.8 | ..... | 3.7 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1895 | ..... | ..... | ..... | 3.8 | 4.0 | 4.0 | 4.2 | 4.2 | 4.3 | ..... | ..... | ..... |
| | | | 1897 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 4.10 | ..... | ..... | 4.10 |
| | | | 1898 | ..... | ..... | 4.40 | ..... | ..... | 4.50 | ..... | ..... | 4.20 | ..... | ..... | 4.10 |
| | | | 1899 | ..... | ..... | 4.00 | ..... | ..... | 4.30 | ..... | ..... | 4.20 | ..... | ..... | 4.30 |
| | | | 1900 | ..... | ..... | 3.90 | ..... | ..... | 4.20 | ..... | ..... | 4.80 | ..... | ..... | 4.70 |
| | | | 1901 | ..... | ..... | 4.74 | ..... | ..... | 4.46 | ..... | ..... | 4.66 | ..... | ..... | 4.20 |
| | | | 1902 | 4.30 | 4.20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

[a] Ansonia Water Company. From storage reservoir on Beaver Brook.

[b] New Haven supply. Dawson reservoir is in Woodbridge on West River, and receives water from Chamberlain reservoir on Sargent River and from Bethany reservoir, 4 miles above Dawson reservoir on West River.

[c] Situated partly in Woodstock. Samples by Dr. F. S. Smith from the source, which is a small natural lake.

[d] Wallingford public supply.

[e] Samples by Dr. H. H. Converse, of Eastford.

[f] Samples by Dr. C. M. Wooster, of Tariffville, from a small private reservoir or lake in East Granby.

*Chlorine determinations for Connecticut*—Continued.

[Parts per million.]

| Source. | Number of samples. | Average. | Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Easton, Mill River (Bridgeport supply) | 12 | 2.9 | 1896 | 3.05 | 2.40 | 2.20 | 2.85 | 2.70 | 2.60 | 2.60 | 2.90 | 3.00 | 2.80 | 3.45 | 3.55 |
| Farmington | 3 | 1.9 | 1897 | ..... | 2.70 | ..... | ..... | ..... | ..... | 1.60 | ..... | ..... | 1.25 | ..... | ..... |
| Hartford, reservoir No. 4 | 12 | 1.8 | 1898 | 1.84 | 1.60 | 1.60 | 1.90 | 1.80 | 1.80 | 1.70 | 1.70 | 1.80 | 1.60 | 1.90 | 2.30 |
| Goshen (Torrington supply) | 12 | 1.5 | 1897 | 1.60 | 1.70 | 1.15 | 1.40 | 1.50 | 1.30 | 1.70 | 1.10 | 1.40 | 1.50 | 2.10 | 2.00 |
| Greenwich, Rockwoods Pond and Putnam Lake | 36 | 3.0 | 1896 | 3.84 | 3.42 | 3.20 | 3.30 | 3.60 | 3.75 | 3.40 | 3.40 | 3.80 | 3.20 | 3.40 | 3.40 |
| | | | 1898 | 3.50 | 3.00 | 2.60 | 2.60 | 2.90 | 2.30 | 2.70 | 2.20 | 2.40 | 2.80 | 3.10 | 3.00 |
| | | | 1901 | 3.34 | 3.70 | 3.50 | 2.94 | 2.60 | 2.26 | 2.58 | 2.74 | 2.30 | 2.00 | 2.72 | 2.10 |
| Griswold (Jewett City supply) | 3 | 2.6 | 1898 | 3.30 | ..... | ..... | ..... | ..... | 2.50 | ..... | ..... | ..... | 2.10 | ..... | ..... |
| Hamden, Lake Wintergreen (New Haven supply) | 38 | 2.4 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2.0 | 2.0 | 2.8 | 3.3 | 2.6 |
| | | | 1890 | 3.0 | 3.0 | 3.3 | 2.5 | 2.5 | 2.8 | 2.8 | ..... | ..... | ..... | ..... | ..... |
| | | | 1895 | ..... | ..... | ..... | 2.2 | 2.4 | 2.4 | 2.6 | 2.6 | 2.5 | ..... | ..... | ..... |
| | | | 1897 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2.45 | ..... | ..... | 3.00 |
| | | | 1898 | ..... | ..... | 2.00 | ..... | ..... | 1.90 | ..... | ..... | 1.80 | ..... | ..... | 1.90 |
| | | | 1899 | ..... | ..... | 1.70 | ..... | ..... | 1.90 | ..... | ..... | 1.60 | ..... | ..... | 2.30 |
| | | | 1900 | ..... | ..... | 1.90 | ..... | ..... | 2.70 | ..... | ..... | 2.80 | ..... | ..... | 3.00 |
| | | | 1901 | ..... | ..... | 3.18 | ..... | ..... | 2.00 | ..... | ..... | 2.20 | ..... | ..... | 2.20 |
| | | | 1902 | 2.20 | 2.40 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Hebron Spring [a] | 5 | 2.3 | 1895 | ..... | ..... | ..... | ..... | 2.6 | 2.2 | 2.2 | 2.3 | 2.2 | ..... | ..... | ..... |
| Kent, reservoir | 17 | 1.6 | 1894 | 1.7 | 1.4 | 1.4 | 1.5 | 1.5 | 1.4 | 1.2 | 1.4 | 2.2 | ..... | 2.1 | 1.9 |
| | | | 1900 | 1.90 | ..... | 1.20 | ..... | 1.50 | ..... | 1.90 | ..... | 1.04 | ..... | 1.86 | ..... |
| Killingly [b] | 12 | 2.3 | 1896 | ..... | 2.00, 1.80, 2.20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1897 | 2.70 | 2.70 | 2.70 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1902 | ..... | ..... | ..... | 2.26 | 2.30 | 2.00 | 2.10 | 2.30 | 2.40 | ..... | ..... | ..... |
| Killingworth (Clinton supply) | 12 | 2.9 | 1901 | 3.80 | 3.70 | 3.44 | 2.30 | 2.74 | 2.14 | 2.56 | 3.10 | 2.20 | 3.40 | 2.94 | 3.00 |
| Manchester: | | | | | | | | | | | | | | | |
| Storage reservoir | 6 | 1.7 | 1900 | 1.80 | ..... | 1.30 | ..... | 1.60 | ..... | 1.80 | ..... | 1.18 | ..... | 1.46 | ..... |
| Distributing reservoir | 6 | | 1900 | 1.70 | ..... | 1.70 | ..... | 1.80 | ..... | 2.10 | ..... | 1.90 | ..... | 1.74 | ..... |
| Meriden, Merimere reservoir | 35 | 1.9 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.5 | 2.0 | 2.0 | 1.8 | 2.0 |
| | | | 1890 | 1.8 | 2.0 | 2.4 | 1.9 | 2.3 | 1.8 | 2.0 | 1.8 | 2.1 | 1.9 | 1.8 | 2.0 |
| | | | 1891 | 2.1 | 2.1 | 1.9 | 1.5 | 2.4 | 2.1 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1899 | 1.70 | 1.70 | 1.40 | 1.50 | 1.40 | 1.10 | 1.30 | 1.60 | 1.70 | 1.80 | 1.80 | 1.80 |
| Middletown, Laurel Brook reservoir | 35 | 2.5 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2.0 | 2.3 | 2.3 | 2.5 | 2.5 |
| | | | 1890 | 2.3 | 2.8 | 2.8 | 2.3 | 3.0 | 2.3 | 2.4 | 2.3 | 2.3 | 2.3 | 2.5 | 2.5 |
| | | | 1891 | 2.0 | 2.1 | 2.3 | 2.3 | 2.5 | 1.8 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1899 | 2.40 | 3.00 | 2.10 | 2.10 | 2.40 | 1.70 | 2.40 | 2.90 | 2.90 | 3.30 | 2.80 | 3.10 |
| Moosup, Moosup Lake [c] | 4 | 2.2 | 1902 | ..... | ..... | ..... | ..... | 2.50 | ..... | 2.16 | ..... | 2.10 | 2.10 | ..... | ..... |
| Morris [d] | 12 | 1.6 | 1901 | 1.78 | 1.60 | 1.50 | 1.70 | 1.56 | 0.96 | 1.46 | 1.58 | 1.90 | 1.50 | 1.90 | 1.42 |

[a] Samples by Dr. C. H. Pendleton from a natural spring in the eastern part of Hebron.

[b] Samples in 1896 collected February 26 by Mr. A. B. Prentice from the various reservoirs of the Danielson supply. Months of 1897 sample collections not given. Samples in 1902 by Mr. G. S. Brown from a tap in Danielson.

[c] Samples by Dr. W. W. Adams, of Moosup. Drainage area partly in Killingly.

[d] Branch of Naugatuck River (Waterbury supply).

*Chlorine determinations for Connecticut*—Continued.

[Parts per million.]

| Source. | Number of samples. | Average. | Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Naugatuck, storage reservoir | 24 | 2.0 | 1895 | 2.2 | 2.2 | 2.0 | 1.5 | 2.1 | 1.9 | 1.7 | 1.8 | 2.0 | 2.3 | 2.7 | 2.2 |
| | | | 1901 | 2.52 | 3.10 | 1.60 | 1.66 | 1.40 | 1.30 | 1.86 | 1.66 | 1.76 | 2.10 | 2.00 | 2.14 |
| Naugatuck River, above Torrington | 50 | 1.6 | 1893 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.8 | 1.4 |
| | | | 1894 | 1.4 | 1.7 | 1.3 | 1.2 | 1.3 | 0.9 | 1.5 | 1.4 | 2.0 | 2.0 | 1.6 | 1.5 |
| | | | 1895 | 1.7 | 1.6 | 1.8 | 1.6 | 1.5 | 1.6 | 1.3 | 1.6 | 1.7 | 2.0 | 2.3 | 2.1 |
| | | | 1896 | 1.80 | 1.65 | 1.40 | 1.30 | 1.65 | 1.55 | 2.20 | 1.90 | 2.30 | 1.65 | 1.50 | 1.8 |
| | | | 1897 | 1.30 | 1.40 | 1.30 | 1.20 | 1.30 | 1.20 | 1.40 | 1.10 | 1.40 | 1.50 | 2.00 | 1.96 |
| New Canaan | 3 | 2.7 | 1897 | ..... | 3.40 | ..... | ..... | ..... | ..... | 2.00 | ..... | ..... | 2.70 | ..... | ..... |
| Norwalk, storage reservoir | 35 | 2.7 | 1894 | 3.5 | 3.0 | 2.6 | 2.6 | 2.4 | 1.8 | 2.2 | 2.2 | 2.4 | 2.9 | 3.3 | 3.3 |
| | | | 1897 | 3.45 | 3.40 | 2.90 | 3.00 | 2.70 | 2.80 | 3.00 | 2.50 | 2.50 | 2.60 | 2.90 | 2.75 |
| | | | 1900 | 3.00 | 2.20 | 2.70 | 2.40 | 2.20 | 1.90 | 2.00 | 2.50 | 2.46 | 2.74 | ..... | 3.06 |
| New Hartford: | | | | | | | | | | | | | | | |
| South reservoir | 3 | 1.3 | 1898 | ..... | 1.20 | ..... | ..... | ..... | 1.10 | ..... | ..... | ..... | 1.70 | ..... | ..... |
| Stone Brook reservoir | 3 | | ..... | ..... | 1.50 | ..... | ..... | ..... | 1.30 | ..... | ..... | ..... | 1.00 | ..... | ..... |
| New Milford | 12 | 1.8 | 1897 | 2.00 | 2.30 | 1.70 | 1.70 | 1.70 | 1.20 | 1.30 | 1.60 | 1.80 | 2.10 | [a]3.60 | 2.90 |
| North Canaan: | | | | | | | | | | | | | | | |
| Norfolk supply | 3 | 1.1 | 1897 | ..... | 1.10 | ..... | ..... | ..... | ..... | 1.10 | ..... | ..... | 1.05 | ..... | ..... |
| Public supply | 18 | 1.2 | 1894 | 1.5 | 0.9 | 1.2 | 1.0 | 1.4 | 1.2 | 1.0 | 1.1 | 1.3 | 1.3 | 1.4 | 1.6 |
| | | | 1900 | 1.20 | ..... | 1.00 | ..... | 1.60 | ..... | 1.30 | ..... | 1.00 | ..... | 1.40 | ..... |
| North Stonington, Wyassup Pond[b] | 6 | 3.1 | 1902 | ..... | ..... | ..... | 3.24 | 2.74 | 3.40 | 2.70 | 3.40 | 3.20 | ..... | ..... | ..... |
| Norwich, storage res. | 47 | 2.6 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2.3 | 2.0 | 2.3 | 1.5 | 2.5 |
| | | | 1890 | 2.0 | 2.5 | 2.5 | 2.8 | 2.1 | 2.3 | 3.1 | 2.4 | 2.5 | 2.7 | 2.9 | 3.4 |
| | | | 1891 | 2.8 | 2.6 | 2.3 | 2.7 | 2.5 | 2.6 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1894 | 3.2 | 2.4 | 3.3 | 2.9 | 3.2 | 2.9 | 3.1 | 3.3 | 3.5 | 2.5 | 3.2 | 3.6 |
| | | | 1899 | 2.20 | 2.50 | 2.20 | 2.30 | 1.60 | 2.00 | 2.20 | 2.60 | 2.10 | 2.10 | 3.20 | 2.40 |
| Orange, Maltby Lake, (New Haven supply) | 20 | 2.3 | 1897 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 2.50 | ..... | ..... | 2.90 |
| | | | 1898 | ..... | ..... | 1.90 | ..... | ..... | 2.30 | ..... | ..... | 2.00 | ..... | ..... | 2.50 |
| | | | 1899 | ..... | ..... | 1.30 | ..... | ..... | 1.50 | ..... | ..... | 1.60 | ..... | ..... | 1.90 |
| | | | 1900 | ..... | ..... | 2.10 | ..... | ..... | 2.70 | ..... | ..... | 3.00 | ..... | ..... | 3.06 |
| | | | 1901 | ..... | ..... | 1.78 | ..... | ..... | 2.44 | ..... | ..... | 2.30 | ..... | ..... | 2.56 |
| | | | 1902 | 2.58 | 2.66 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Oxford: | | | | | | | | | | | | | | | |
| Hatter's Spring[c] | 6 | 1.7 | 1895 | ..... | ..... | ..... | 1.8 | 1.8 | 1.5 | 1.7 | 1.7 | 1.9 | ..... | ..... | ..... |
| Towantic Spring[d] | 5 | 2.2 | 1895 | ..... | ..... | ..... | 2.2 | 2.5 | 2.0 | 2.1 | 2.0 | ..... | ..... | ..... | ..... |
| Plainville | 3 | 1.9 | 1897 | ..... | 2.20 | ..... | ..... | ..... | ..... | 1.90 | ..... | ..... | 1.70 | ..... | ..... |
| Plymouth (Terryville supply) | 3 | 1.9 | 1897 | ..... | ..... | 2.30 | ..... | ..... | ..... | 1.60 | ..... | ..... | ..... | 1.70 | ..... |
| Portland | 3 | 2.4 | 1897 | ..... | 2.30 | ..... | ..... | ..... | ..... | 2.30 | ..... | ..... | 2.50 | ..... | ..... |
| Ridgefield | 12 | 2.24 | 1901 | 2.74 | 2.70 | 2.20 | 2.10 | 2.50 | 1.50 | 1.80 | 2.30 | 2.00 | 2.14 | 2.26 | 2.64 |
| Rockville, Schenipsit Lake | 23 | 1.6 | 1890 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.7 | 1.5 | 1.5 | 1.8 | 2.6 |
| | | | 1891 | 1.8 | 1.1 | 1.3 | 1.8 | 1.5 | 1.8 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1900 | 1.20 | 1.70 | 1.30 | 1.50 | 1.30 | 1.30 | 1.50 | 1.40 | 1.50 | 1.30 | 1.60 | 1.46 |
| Salisbury (Lakeville supply) | 3 | 0.9 | 1898 | ..... | .80 | ..... | ..... | ..... | .70 | ..... | ..... | ..... | 1.30 | ..... | ..... |

[a] Not included in average.
[b] Samples by Mr. E. H. Knowles, of North Stonington.
[c] Samples by Dr. Lewis Barnes from a natural spring located on the west side of Little River Valley, in Oxford.
[d] Samples by Dr. Lewis Barnes from a natural spring located about half a mile east of Hatter's Spring.

*Chlorine determinations for Connecticut*—Continued.

[Parts per million.]

| Source. | Number of samples. | Average. | Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seymour, Fountain Water Co. (Ansonia supply) | 12 | 2.3 | 1898 | 2.70 | 2.60 | 2.20 | 2.30 | 2.20 | 2.10 | 2.20 | 2.40 | 2.30 | 2.60 | 1.80 | 2.20 |
| Shelton | 3 | 3.1 | 1897 | ..... | 2.90 | ..... | ..... | ..... | ..... | 3.30 | ..... | ..... | 3.00 | ..... | ..... |
| Simsbury | 3 | 1.8 | 1898 | ..... | ..... | 1.30 | ..... | ..... | 2.00 | ..... | ..... | ..... | 2.10 | ..... | ..... |
| Southington (New Britain supply): | | | | | | | | | | | | | | | |
| Roaring Brook | 12 | 1.7 | 1899 | 1.50 | 1.40 | 0.70 | 1.60 | 1.60 | 1.80 | 2.00 | 2.20 | 1.70 | 2.00 | 2.10 | 2.20 |
| Shuttle Meadow Lake | 46 | 1.9 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.3 | 1.8 | 2.0 | 1.5 | 1.8 |
| | | | 1890 | 2.3 | 2.5 | 2.3 | 2.5 | 2.3 | 2.0 | 2.0 | 1.8 | 2.2 | 1.8 | 1.8 | 1.8 |
| | | | 1891 | 1.7 | 1.9 | 1.6 | 2.0 | 2.0 | 1.6 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1894 | 1.9 | ..... | 1.9 | 2.0 | 2.1 | 2.0 | 2.0 | 2.0 | 2.9 | 2.3 | 2.1 | 1.8 |
| | | | 1899 | 1.50 | 1.20 | 1.40 | 1.50 | 1.90 | 2.70 | 2.30 | 1.70 | 1.90 | 2.00 | 2.10 | 2.10 |
| South Manchester: | | | | | | | | | | | | | | | |
| Porter reservoir | 24 | 1.8 | 1900 | 1.40 | ..... | 1.50 | ..... | 1.90 | ..... | 1.80 | ..... | 1.90 | ..... | 2.30 | ..... |
| Taylor storage res. | | | 1894 | 2.1 | 1.5 | 1.3 | 1.7 | 1.6 | 1.6 | 2.0 | 2.2 | 1.9 | 2.5 | 2.3 | 2.1 |
| | | | 1900 | 1.70 | ..... | 1.50 | ..... | 1.50 | ..... | 1.70 | ..... | 1.58 | ..... | ..... | 2.10 |
| Stafford Springs[a] | 6 | 1.6 | 1900 | 1.60 | ..... | 1.40 | ..... | 1.50 | ..... | 1.50 | ..... | .94 | ..... | 2.50 | ..... |
| Stamford, Trinity Lake, N. Y. | 24 | 2.3 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.8 | ..... | 2.8<br>2.3 | 2.6 | 1.8 |
| | | | 1890 | 2.5 | 2.4 | 2.3 | 2.3 | 2.3 | 1.8 | 2.0 | ..... | ..... | ..... | ..... | ..... |
| | | | 1899 | 2.10 | 1.50 | 1.50 | 1.60 | 1.90 | 1.60 | 2.00 | 2.70 | 2.70 | 3.20 | 4.00 | 3.10 |
| Stonington, storage reservoir | 22 | 5.1 | 1894 | ..... | 5.8<br>6.0 | 4.4 | 3.1 | 5.4 | ..... | 5.2 | 5.5 | ..... | 5.7 | 7.0 | 6.7 |
| | | | 1900 | 5.00 | 4.50 | 4.30 | 4.30 | 4.50 | 3.60 | 4.30 | 3.10 | 4.86 | 5.00 | 5.30 | 5.60 |
| Thomaston: | | | | | | | | | | | | | | | |
| Storage reservoir | 35 | 1.6 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.0 | 2.0 | 1.8 | 1.8 | 1.3 |
| | | | 1890 | 1.8 | 1.8 | 1.4 | 1.9 | 1.3 | 1.1 | 1.5 | 1.7 | 1.7 | 1.5 | 1.5 | 1.8 |
| | | | 1891 | 1.6 | 1.3 | 1.2 | 1.6 | 1.4 | 1.3 | ..... | ..... | ..... | ..... | ..... | ..... |
| | | | 1894 | 2.0 | 2.0 | 2.1 | 1.7 | 1.7 | 1.4 | 1.6 | 1.6 | 1.9 | 1.8 | 2.0 | 2.6 |
| Spring[b] | 12 | 1.6 | 1894 | 1.3 | 1.3 | 1.5 | 1.4 | 1.5 | 1.2 | 1.5 | 1.6 | 1.9 | 1.9 | 2.0 | 2.0 |
| Union[c] | 6 | 1.4 | 1895 | ..... | ..... | ..... | 1.4 | 1.2 | 1.3 | 1.4 | 1.5 | 1.8 | ..... | ..... | ..... |
| Voluntown: | | | | | | | | | | | | | | | |
| Beachdale Pond[d] | 9 | 2.7 | 1902 | ..... | ..... | ..... | 2.36 | 2.54 | 2.18 | 2.62 | 2.90 | 2.80 | ..... | ..... | ..... |
| Beach Pond | | | 1896 | ..... | 3.3 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Great Meadow Brook | | | 1896 | ..... | 3.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Mt. Misery Stream | | | 1896 | ..... | 2.7 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Waterford, Lake Konomoc (New London supply) | 24 | 3.3 | 1894 | 3.8 | 3.3 | 3.3 | 3.5 | 3.5 | 3.3 | 3.5 | 3.4 | 2.7 | 3.7 | 3.6 | 3.8 |
| | | | 1899 | 3.10 | 3.10 | 3.10 | 2.90 | 3.20 | 3.00 | 3.30 | 2.70 | 2.90 | 3.10 | 3.10 | 3.20 |
| Watertown, Farm Brook (Waterbury supply) | 35 | 1.7 | 1898 | ..... | 1.60 | 1.20 | 1.20 | 1.60 | 1.50 | 1.90 | 1.10 | 1.60 | 2.70 | 1.40 | 1.40 |
| | | | 1899 | 1.20 | 1.70 | 1.30 | 1.20 | 1.40 | .90 | 1.60 | 1.70 | 1.90 | 2.10 | 3.10 | 2.50 |
| | | | 1900 | 1.90 | 1.90 | 2.30 | 1.80 | 1.30 | 1.10 | 1.90 | 1.80 | 1.64 | 2.00 | 2.90 | 1.60 |
| Westbrook[e] | 5 | 6.7 | 1895 | ..... | ..... | ..... | ..... | 4.7 | 6.8 | 7.1 | 7.4 | 7.3 | ..... | ..... | ..... |
| West Cornwall: | | | | | | | | | | | | | | | |
| Lake[f] | 6 | 1.1 | 1895 | ..... | ..... | ..... | .9 | 1.1 | 1.2 | 1.1 | 1.1 | 1.4 | ..... | ..... | ..... |
| Spring[g] | 6 | 1.3 | 1895 | ..... | ..... | ..... | 1.0 | 1.2 | 1.3 | 1.2 | 1.3 | 1.8 | ..... | ..... | ..... |

[a] Roaring Brook; part of drainage area in Union.
[b] Samples by Dr. R. S. Goodwin from a natural spring located in the western part of Thomaston.
[c] Samples by Dr. F. L. Smith, of Stafford Springs, from a small natural lake located in the western part of Union and used as a private water supply.
[d] Samples by Rev. E. Dewhurst, of Voluntown.
[e] Samples by Dr. T. B. Bloomfield from Dies' Pond.
[f] Samples by Mr. T. S. Gold from a small natural lake.
[g] Samples by Mr. T. S. Gold from a natural spring which is used as a private supply.

*Chlorine determinations for Connecticut*—Continued.

[Parts per million.]

| Source. | Number of samples. | Average. | Year. | January. | February. | March. | April. | May. | June. | July. | August. | September. | October. | November. | December. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| West Hartford: | | | | | | | | | | | | | | | |
| Reservoir No. 1... | 58 | 1.6 | 1898 | 1.70 | 1.64 | 1.20 | 1.70 | 1.60 | 1.50 | 1.90 | 1.40 | ..... | 1.20 | 1.80 | 1.70 |
| No. 2... | | | 1898 | 1.50 | 1.50 | 1.30 | 1.70 | 1.60 | 1.50 | 1.60 | 1.10 | 1.20 | 1.10 | 1.50 | 1.40 |
| No. 3... | | | 1898 | 1.80 | 1.50 | 1.40 | 1.70 | 1.80 | 1.80 | 2.00 | 1.50 | 1.50 | 1.40 | 1.50 | 1.50 |
| No. 5... | | | 1898 | 1.60 | 1.70 | 1.40 | 1.70 | 1.60 | 1.50 | 1.90 | 1.30 | 1.40 | 1.20 | ..... | 1.50 |
| No. 6... | | | 1898 | 1.24 | 1.30 | .90 | 1.50 | 1.50 | 1.50 | 1.60 | 1.20 | 1.40 | 1.20 | 1.50 | 1.40 |
| W. Haven, storage res. | 12 | 6.0 | 1895 | 6.6 | 6.7 | 6.3 | 5.4 | 5.8 | 5.8 | 4.8 | 6.0 | 4.7 | 6.5 | 6.1 | 6.8 |
| Winchester, Highland Lake and Mad River (Winsted supply) | 24 | 1.3 | 1895 | 1.9 | 1.9 | 1.9 | 1.4 | 1.4 | 1.5 | 1.4 | 1.4 | 1.4 | 1.5 | 1.3 | 1.4 |
| | | | 1901 | 1.56 | 1.30 | 1.36 | 1.22 | 1.24 | 1.10 | 1.12 | .90 | .94 | .94 | .90 | 1.16 |
| Windsor Locks | 3 | 1.5 | 1897 | ..... | 1.65 | ..... | ..... | ..... | ..... | 1.50 | ..... | ..... | 1.45 | ..... | ..... |
| Wolcott, storage res. (Southington supply) | 12 | 1.9 | 1894 | 2.5 | 2.1 | 2.0 | 2.0 | 1.8 | 1.5 | 1.4 | 1.6 | 1.7 | 2.0 | 2.4 | 2.3 |
| East Mountain storage res. (Waterbury supply) | 23 | 2.0 | 1889 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 1.9 | 1.8 | 2.0 | 1.9 | 2.0 |
| | | | 1890 | 2.3 | 1.5 | 1.9 | 2.8 | 2.3 | 2.1 | 2.6 | 2.3 | 2.0 | 1.9 | 2.0 | 1.9 |
| | | | 1891 | 1.8 | 1.5 | 1.8 | 2.2 | 1.6 | 1.8 | ..... | ..... | ..... | ..... | ..... | ..... |
| Woodbury | 3 | 1.9 | (a) | 1.60 | ..... | ..... | ..... | ..... | ..... | 1.80 | ..... | ..... | ..... | 2.40 | ..... |

a No year given.

## THE ISOCHLORS OF NEW YORK.

New York produces more salt than any other State in the Union, and it would be natural to suppose that these salt deposits would affect materially a large portion of the waters in this region. Such, however, has not been found to be the case. In this State the salt beds have only a local influence, and normal waters may be found within a very narrow range of these deposits. The districts from which salt is obtained are, Ithaca, Tompkins County; Le Roy, Genesee County; Syracuse, Onondaga County; Warsaw, Wyoming County, and York, Livingston County.

In all of these districts the normal is below 0.4 part per million, and a water contaminated by salt from these deposits would in most cases be so very much higher in chlorine that it could hardly be mistaken for ordinary pollution.

The determination for the normal chlorine lines of New York State (Pl. V) is the result of analyses made by the author at Mount Prospect laboratory. The time of making analyses extended over a period of six years, and the results represent many thousand determinations of chlorine. The largest number of samples were examined on Long Island, Staten Island, and near the coast on the mainland where the differences in chlorine were greatest over a limited area. It will be seen that the Catskill and Adirondack mountains cause deflections

toward the coast in the isochlors. This is due to the precipitation on their southern slopes of the moisture in the lower layers of the atmosphere which naturally contain the greater portion of the salt.

It will also be noted that Long Island has a remarkable effect in lowering the chlorine on the mainland. The lowest isochlor on the mainland is 3 parts per million, whereas if it were not for the protecting influence of the island it would undoubtedly be 6 parts per million. Artesian wells in Manhattan Borough have been found which have a chlorine content of as low as 2 parts per million, but these may be considered to be below normal and to consist of water from some distance north of the point from which they were drawn.

The following is a list of some of the waters which have had an influence upon the establishment of the isochlors for New York State:

*Chlorine determinations for New York.*

[Parts per million.]

| Source. | Chlorine. |
|---|---|
| Albany County: | |
| Cooksburg, Catskill Creek | 0.4 |
| Delaware County: | |
| East Branch, reservoir | 1.3 |
| East Branch reservoir, Tonnetta Brook | 1.3 |
| Dutchess County: | |
| Clinton Hollow, Little Wappinger Creek | .6 |
| Fishkill, Whalen Pond | 1.0 |
| Sprout Pond | 1.0 |
| Millerton, Wobotuck Creek | 1.0 |
| Franklin County: | |
| Kushaqua, Lake Kushaqua | .3 |
| Saranac Lake, lake | .3 |
| Saranac River | .3 |
| Greene County: | |
| Ashland, Batavia Kill | .4 |
| East Durham, Catskill Creek | .5 |
| Prattsville, Scoharie Creek | .6 |
| Jefferson County: | |
| Watertown, water supply | .3 |
| Lewis County: | |
| Boyds Corner reservoir, Cold Spring Brook | 1.0 |
| Do | 1.2 |
| Livingston County: | |
| Sonyea, spring | 0.3 |
| New York County: | |
| Williamsbridge | 2.2 |
| Orange County: | |
| Middletown, Highland Lake | 1.0 |
| Mohegan Lake | .9 |
| Tuxedo Park, spring | 1.7 |
| Oswego County: | |
| Oswego, McKenzies Pond | .3 |
| Silver Lake | .3 |
| Putnam County: | |
| Kirk Lake | 1.4 |
| Lake Gilead | 1.4 |
| Middle Branch, reservoir | 1.4 |
| Rensselaer County: | |
| Troy, Lake Ida | .4 |
| Rockland County: | |
| Hillburn | 1.4 |
| Suffern, Mahwah River | 1.4 |
| Ramapo River | 1.4 |
| Sullivan County: | |
| Hasbrouck, Neversink River | .6 |
| Liberty, spring No. 1 | .6 |

*Chlorine determinations in New York*—Continued.

[Parts per million.]

| Source. | Chlorine. |
|---|---|
| Sullivan County—Continued. | |
| Liberty, spring No. 2 | 0.7 |
| No. 3 | .6 |
| Ulster County: | |
| Grand Hotel, station | .4 |
| Kingston, Esopus Creek | .8 |
| Oakes, Catskill Creek | .4 |
| Randall Bridge, Rondout Creek | .8 |
| Rifton, Black Creek | .6 |
| Shokan, Esopus Creek | .5 |
| Warren County: | |
| Glens Falls, Hudson River | .4 |
| Sodom, reservoir | 1.4 |
| Westchester County: | |
| Croton Lake | 1.5 |
| Glen Park, pumping station | 2.2 |
| Katonah, Cross River | 1.8 |
| Kensico, reservoir | 2.2 |
| Muscoot, reservoir | 1.5 |
| Rye Pond | 2.6 |
| Tarrytown, spring | 2.9 |
| Yonkers, Grassy Sprain reservoir | 2.8 |
| Richmond County, Staten Island: | |
| Clifton, water supply | 6.0 |
| Richmond, Turnpike station, Crystal Water-Supply Company | 6.2 |
| Stapleton, water supply | 6.0 |
| Tottenville, water supply | 6.0 |
| Nassau County, Long Island: | |
| East Meadow Stream | 4.6 |
| Hempstead, well | 3.0 |
| stream at source | 3.8 |
| Massapequa, stream | 4.0 |
| Roslyn, well | 4.6 |
| Suffolk County, Long Island: | |
| Amagansett, well | 16.5 |
| Aqueboque, well | 16.4 |
| Suffolk County, Long Island—Continued. | |
| Babylon, pond | 5. |
| stream | 4. |
| stream | 4. |
| stream | 4. |
| Sumpawampus Creek | 4. |
| waterworks | 4. |
| well | 5. |
| Brookhaven, Connetquot River | 4. |
| Bridghampton, well 1½ miles southeast of station | 30. |
| Central Islip, well | 4. |
| Deer Park, well | 4. |
| East Moriches, Mastic River | 5. |
| Great River, Connetquot River | 4. |
| Green Lawn, stream | 6. |
| Greenport, well | 61. |
| Huntington, stream | 7. |
| town supply | 6. |
| Kings Park, stream | 7. |
| Islip, Bayshore supply | 4.4 |
| Beaver Brook | 4.1 |
| Doxies Stream | 4.4 |
| Orowoc Creek | 4.4 |
| Stellenwerf Stream | 4. |
| well | 4. |
| Long Pond | 6. |
| Melville, well | 4. |
| Mellville Station, well | 4. |
| Manor, stream | 7. |
| well | 4.8 |
| well | 6. |
| Moriches, well | 7. |
| Medford Station, well | 5. |
| Mattituck, pond | 12. |
| Montauk, well | 15. |
| Northport, pond | 6. |
| town supply | 6. |

*Chlorine determinations in New York*—Continued.

[Parts per million.]

| Source. | Chlorine. | Source. | Chlorine. |
|---|---|---|---|
| Suffolk County, Long Island—Continued. | | Suffolk County, Long Island—Continued. | |
| Patchogue, pond | 4.6 | Sag Harbor, well | 17.2 |
| river | 4.0 | Sayville, Edwards Creek | 6.8 |
| Swan Creek | 4.4 | Patchogue supply | 5.0 |
| Tuttle Creek | 5.2 | Smithtown, stream | 4.2 |
| water supply | 4.4 | Selden, Sumpawampus Creek | 4.6 |
| well | 6.1 | well | 5.2 |
| Port Jefferson, town supply | 4.4 | Wading River, spring | 10.0 |
| Ronkonkoma, lake | 4.4 | | |

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